ENERGY DEMAND STRUCTURES AND URBAN DEVELOPMENT IN INDIA

Final Report

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Tata Energy Research Institute
7, Jor Bagh, New Delhi - 110 003

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Project Team

Dr. Ranjan Kumar Bose	Fellow
Ms. Maithili Iyer	Research Associate

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Ranjan Kumar Bose
Maithili Iyer

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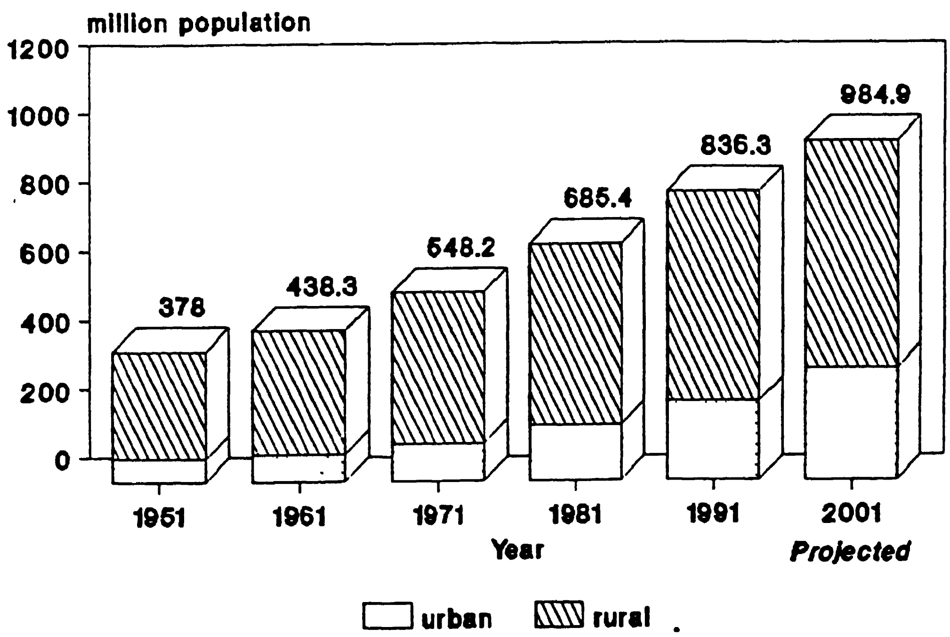
Chapter 1

INTRODUCTION

1.1 Urbanisation trend

Over the past four decades, the number of people living in India has more than doubled - from 350 million 1947 to nearly 800 million in 1988 [GOI, 1988]. During the same period, our urban population has been growing almost twice as fast, and has in fact quadrupled from 50 million in 1947 to over 200 million in 1988 - with one in four persons staying in urban areas [NIUA, 1988]. By the turn of the century, the urban population is expected to be 326 million - nearly one-third of the total population (Figure 1.1).

Fig.1.1: Population distribution by rural and urban



There are 3301 urban settlements in India, ranging in size from small towns to giant metropolises with 9 million and more. During the decade 1971-1981, these metropolises grew at an average rate of 46.2 per cent - with growth through migration accounting for about two-fifths, growth through natural increase another two-fifths and reclassification (new towns and area changes) about one-fifth. There is also a skewness in distribution of population among different cities with a high concentration of the urban population in a few large size cities. By the year 2001, it is estimated that the number of cities with the population of more than one million each (which in 1981 numbered 12) will have gone up to about 40 [GOI, 1988]. Now, in demographic projections made for just over a decade hence, urban India will have become a reality of staggering magnitude with the number of urban citizens equal to the total population in USA and USSR combined!

1.2 Economic development and urbanisation

Urbanisation concentrates populations and economic activities. It involves transfer of work force from agriculture to industry and services, and within industry, from low energy intensity processing of primary products to more energy intensive metals and chemical products, inter alia. In 1950-51, the contribution of urban India to net domestic product was 29 per cent. This grew to 37 per cent in 1970-71. Given the present economic trends, it is likely to increase to over 60 per cent by 2001. Thus, about 35 per

cent of the population will contribute over 60 per cent of the net domestic product [GOI, 1988].

1.3 Urbanisation and energy

Urbanisation shifts production activities formerly undertaken in the home with little or no energy to outside producers who do use energy. One of the largest changes is the daily travel of urban residents, primarily but not exclusively, to work. Personal transportation in rural areas generally entails little or no fuel use, while urban transportation does, particularly as income increases. The removal of rural population from farms to distant cities requires the transportation of food, which previously required little or no transportation. Urban households purchase a large share of their goods and services than rural households, and the commercial providers of these goods and services in the city are more likely to use fuel or other energy forms in production than did the rural household.

Higher density living also induces substitutions of modern for traditional energy forms. These substitutions occur in domestic, as well as industrial and commercial uses. Usually, these energy substitutions permit a smaller total quantity of input energy to supply the same or larger energy outputs, dampening the tendency for urbanisation to increase energy intensity of production. However, rising per capita incomes associated with urbanisation, increase demands for both end-use energy and more energy intensive products and services.

Further, the relative position of the urban poor in terms of energy use is worsening in many cases. They have less access to energy resources and technologies and spend more on energy as a proportion of the limited family budget. It should therefore be no surprise that urbanisation increases energy use, both per capita and per unit of output.

Thus, the implications of this rapid pace of urbanisation on the energy scene are :

- Shift from traditional energy sources to modern fuels;
- Increase in energy use on account of demand for new services in households such as electric lighting; cooking with LPG, kerosene or electricity, instead of wood or coal; refrigeration, air-conditioning;
- Greater dependence on monetised formal supply networks to meet the growing energy demand;
- Present urban energy system is inequitable, causing undue hardship to the urban poor;
- Increased requirements for personal transportation and greater dependence on personal vehicles on account of separation of places of work from residence;
- Greater dependence on oil based motorised forms of transport;
- Increased incomes and better living styles leading to larger energy use per capita;
- Increased requirements of commercial fuel for industrial and commercial activities.

1.4 Scope and objectives of the study

We know that urbanisation is a major characteristic of economic development, and involves many structural changes throughout the economy that have important implications on energy use. Yet, the relationship between energy and urban development has not been well understood, particularly in the cities of the developing countries. In this era of energy and resource scarcities, the need to develop such an understanding is vital, if we want to shape the future of our cities in terms of sustainable urban growth. Unless adequate measures are taken now to enhance energy supply and optimize its use, the shortage may constrain urban development. It is necessary therefore, to understand the linkages between urbanisation, energy use and other related parameters in different sectors to plan appropriate urban development policies, within the framework of the national economy and social development.

The energy using activities in cities can be broadly classified into the following categories under different sectors :

- Domestic : Cooking, water heating, lighting, space heating, space cooling and others.
- Transport : Intra city passenger travel demand.
- Commercial : Lighting, space heating and space cooling.
- Industry : Process heating, motive power, captive power, lighting

There has been increasing use of commercial fuels to support these activities. To have a better understanding of the urban development process and energy consumption patterns and the relationship between them, the study would look into each of the four sectors separately.

The specific objectives of the study are to

(a) develop an urban energy data base from existing studies and analyse the various factors that influence energy demand in the domestic, transport (passenger), industry and commercial sectors of urban economy.

(b) understand the implications of sectoral energy use in the existing inter-linkages and inter-dependencies of various urban activities.

(c) forecast urban energy demand of various forms in the domestic and transport (passenger) sector during 2000-01.

1.5 **Coverage of the study**

This chapter introduces the study. An overview of the energy scene in India is presented in Chapter 2. In the subsequent chapters - 3, 4, 5 and 6 we give an overview of the energy consumption pattern in urban areas in the domestic, transport (passenger), industry and commercial sectors respectively. Apart from looking at consumption patterns of energy and the changes that have taken place over time, we also have analysed various factors and policies that have a bearing on energy demand pattern in urban areas. Urban energy demand projections are made for 2001 by

analysing the time series data for both domestic and transport sector.

The study has been constrained by the fact that the existing database in regard to energy consumption patterns in cities in India is very limited. Also, not many studies have been done on the issues relating to the urban development process and energy consumption patterns and the relationship between them. In this study, an attempt is made to identify the key factors influencing urban energy demand, by analyzing secondary data.

Chapter 2

ENERGY USE PATTERNS IN INDIA

2.1 Economic growth and energy consumption

Energy consumption is closely linked to economic growth. In India, the trends in commercial energy consumption show high rates of growth relative to rate of growth in real GDP, which was on an average 4 per cent per annum between 1970-71 to 1986-87 [TERI, 1989]. There has been, therefore, an increase in commercial energy intensity. The overall commercial energy intensity in the Indian economy has shown an upward trend from about 54 toe/Rs million GDP to about 60 toe/Rs million GDP during the period 1970-71 to 1987-88. This has been due to

- mechanization in agriculture;
- a shift in freight traffic from rail to road;
- increasing use of personalized modes of transport;
- increased personal incomes and urbanisation leading to higher household energy use.

2.2 Trends in energy consumption in the economy

In India, commercial energy sources (coal, oil, gas and electricity) accounted for about 58 per cent of the total energy used in the country during 1984-85 [GOI, 1986]. This share is projected to grow to almost 80 per cent by 2004-05. The total energy demand in 1989-90 was 1025 million tonnes of

coal replacement (mtcr)[a]. About two-thirds of this demand was met through the commercial sources of energy, the rest coming from traditional sources.

Between 1984-85 and 1989-90, total energy demand is estimated to have grown at the rate of 6.7 per cent per year - from 741 mtcr to 1025 mtcr (Table 2.1). This growth rate is expected to fall to an average of 4.5 per cent per annum during the Eighth Plan Period and edge up to 5 per cent per annum between 1994-2000.

Table 2.1. Consumption of commercial and non-commercial energy

	Unit	1984-1985	1989-1990	1994-1995	1999-2000	2004-2005
Total energy demand	mtcr	741	1025	1276	1631	2046
Commercial energy	%	58.1	66.8	71.0	74.9	79.5
Non-commercial energy	%	41.9	33.2	29.0	25.1	20.5

Source : [CMIE, 1990]

The total energy demand is projected to grow nearly twofold from 1025 mtcr in 1989-90 to 2046 mtcr in 2004-05. The share of commercial energy in the total has been increasing from 58 per cent in 1984-85 to 67 per cent in 1989-90 and is expected to increase further to about 80 per cent by 2004-05 (Table 2.1).

a Energy data in India is compiled in either coal replacement units or in coal/oil equivalent units, that measure the calorific content of an energy source. By using coal replacement units, one effectively compiles data on useful energy demand. It is therefore evident that while coal or oil equivalent units are used for aggregation, the share of non-commercial energy will be higher.

The main task for energy planners now is to find ways and means of meeting this order of energy demand in future, within the constraint of capital resources faced by the country. There is a need to move away from excessive dependence on oil, the demand for which is expected to grow from 32.3 million tonne (mt) in 1982-83 to 72.7 mt in 1999-2000, as estimated by the Planning Commission.

2.3 Sectoral share of energy demand

In the total energy consumption - commercial and non-commercial together - the household sector accounts for the major share, followed by industries then transport and lastly the agriculture sector, as shown in Table 2.2. It can be observed that the household share is expected to go down from 40.8 per cent in 1989-90 to about 33.4 per cent in 2004-05. During the same period the share of the agriculture sector is also expected to go down from 3.9 per cent to nearly 2.9 per cent. In the case of both industries and transport, the share in the total energy consumption is expected to go up.

Table 2.2. Sectoral share (%) in total energy demand

Sectors	1984-1985	1989-1990	1994-1995	1999-2000	2004-2005
Industry	18.2	21.1	22.7	24.8	25.2
Transport	15.0	17.1	18.9	19.6	21.6
Agriculture	3.8	3.9	3.7	3.4	2.9
Household					
Commercial	5.0	7.6	9.3	10.9	12.9
Non-commercial	41.9	33.2	29.0	25.1	20.5
Others	2.2	2.3	2.5	2.8	3.0
Auxiliary consumption and losses etc.	13.9	14.8	13.9	13.4	13.9

Percentages are worked out with respect to mtcr unit.
Source : [CMIE, 1990]

2.4 Commercial energy supply and consumption

Table 2.3 gives an overview of the commercial energy supply and consumption in the last decade.

Table 2.3. Commercial energy - production, supply and consumption

(in mtoe)

	1975-76	1980-81	1986-87	1987-88
Production	63.80	72.54	125.18	133.12
Coal	50.33	55.89	81.28	88.51
Oil	8.45	10.45	30.49	30.37
Gas	2.03	2.02	8.45	9.83
Primary electricity	2.99	4.18	4.96	4.42
Imports	15.42	24.08	17.22	19.51
Coal	-0.22	0.68	1.18	1.46
Oil	15.64	23.40	16.04	18.05
Net availability[a]	59.80	68.23	97.44	103.35
Coal	33.91	31.97	41.21	43.09
Oil	20.32	28.42	40.89	43.72
Gas	0.56	0.88	3.85	3.22
Electricity	5.01	6.96	11.49	13.32
Consumption	59.80	68.23	97.44	103.35
Agriculture	2.57	1.59	2.80	3.62
	(4.30)	(2.33)	(2.87)	(3.50)
Industry	32.90	35.77	50.64	53.10
	(55.02)	(52.43)	(51.97)	(51.38)
Transport	14.58	17.00	22.00	23.73
	(24.38)	(24.92)	(22.58)	(22.96)
Domestic	5.62	6.87	10.76	11.61
	(9.40)	(10.07)	(11.04)	(11.23)
Others	4.13	1.72	2.24	2.39
	(6.90)	(2.52)	(2.30)	(2.31)
Non-energy use	-	5.28	8.99	8.90
		(7.73)	(9.24)	(8.62)

Note : a This is net availability after accounting for stock changes, conversion and T&D losses.
Figures in parentheses are expressed in percentages.

Source : [TERI, 1990]

The notable achievement was a reduction in oil imports from 23.4 mt in 1980-81 to about 16.04 mt in 1986-87. This

was due to the indigenous production of oil which went up after 1980-81. Also, the total commercial energy consumption in the period 1980-81 to 1987-88 increased at an annual growth rate of 6.1 per cent.

In terms of sectoral shares in commercial energy consumption, there has been no major shift (Table 2.3). The domestic sector accounts for about 11 per cent of commercial energy use. A little over 50 per cent of commercial energy is consumed in the industries. The share of the transport sector is about 23 per cent and that of agriculture nearly 4 per cent. But, if non-commercial sources of energy are included, households become the major user sector.

Electricity, which has been growing at a rate of 9.7 per cent per annum during the period 1980-81 and 1987-88, is used mostly in industry and agriculture. Gas is used mostly as a feedstock for fertilizer production. Also, more than 90 per cent of the total commercial energy is used in urban areas only.

2.5 Non-commercial energy

The estimates of consumption of non-commercial energy sources are based on a number of assumptions[a] and, hence, are

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a These estimates are based on the assumption of invariant per capita annual requirements of domestic energy and invariant composition of traditional fuels. The estimates of total consumption of domestic energy are first worked out by multiplying the per capita energy requirements with the population of the respective years. The share of non-commercial energy is then estimated by deducting the estimated consumption of commercial energy.

not as accurate as those for the commercial sources of energy. Nevertheless, the fact that the traditional sources account for the bulk of the energy consumption in the domestic sector, is confirmed by the available data from various sources. Non-commercial sources accounted for 93 per cent of the total energy demand in this sector in 1982-83. Among the non-commercial fuels consumed by households, firewood continued to be the major fuel, meeting 63 per cent of the needs; followed by animal dung (22 per cent) and crop residue (15 per cent).

Chapter 3

DOMESTIC SECTOR

3.1 Introduction

Lighting, cooking and water heating are the major domestic activities requiring fuel. Energy in the form of electricity is also used for running fans, electric irons, refrigerators, washing machines and other appliances. Common sense and the number of studies from around the world suggest that a few key factors have a dominant impact on the amount of energy consumed by households. The principal determinants of energy demand include income, settlement size, family size, the price or personal costs of obtaining fuels and the efficiency of end-use equipment. Most of these factors are interrelated and have major implications for policies to remedy household energy problems.

Unfortunately, it is often difficult to establish the strength of these relationships due to the lack of consistent, comparable survey data based on sufficiently large and statistically valid samples. In India, a study of urban household energy patterns proves to be difficult, since there is no agency collecting the relevant data on a regular basis. The first study in this area was conducted by the National Council of Applied Economic Research (NCAER), New Delhi. Nearly 4000 urban households spread all over India were surveyed by NCAER in 1977-78 and a macro level analysis was done, results of which were published in 1985 [NCAER, 1985]. At the micro level, a number of city specific studies

(based on urban household surveys) have also been done. The cities which have been studied are Hyderabad [Alam, 1985], Bangalore [Reddy and Reddy, 1983], Pune [Nair and Krishnayya, 1985], Raipur [Macauley, 1986], Ahmedabad [Ganapathy and Padmanabhan 1985] and Delhi [TERI, 1990]. The Tata Energy Research Institute (TERI), New Delhi also carried out urban household survey in ten cities spread all over the country during 1987 [TERI, 1988]. However, in view of the variations in coverage, methodology and focus in the different studies, comparisons between them become difficult.

In this chapter, we would be looking at the effects of urbanisation on household energy patterns. We have in this study, attempted to analyse the TERI survey data in the ten cities to understand the key factors influencing the urban household energy demand. In addition, data from other studies, have also been used to supplement the major findings of the TERI survey data.

The specific issues that have been covered in the study with regard to the domestic sector are the following :

* Analysis of energy use by
  - Fuel type : LPG, kerosene, firewood, soft coke, dungcake and electricity
  - End use : Cooking, water heating, space heating, space cooling, lighting and others.

* Variations in energy consumption patterns :
  - Between urban and rural areas
  - Across regions
  - By income class
  - Over time
  - Across different size of settlement
* Ownership pattern of electrical appliances in urban households across different regions
* Demand for various fuels and in different income categories of urban households during 1991 and 2001.

Finally, energy demand projections are extrapolated for urban households during 1994-95, 1999-2000 and 2004-05.

3.2 Economic development, urbanisation and energy use

To establish the relationship between the level of economic development, urbanisation and energy consumption pattern in households, we start with a comparison of the nature of energy consumption among developed and developing countries. Data on these parameters are compiled in Table 3.1 for 23 countries.

A simple correlation exercise is carried out using the data in Table 3.1 the results of which are presented in Table 3.2 .

Table 3.1. Energy use and its related parameters : comparison between countries

Country	GNP per capita (US$)	Urbanisation (%)	Traditional fuel share (%)	Electricity per capita (kgoe)	Per capita energy use in households: Gross (kgoe)	Per capita energy use in households: Useful (kgoe)
India	260	24	87.2	4	120	21.8
Pakistan	380	29	70.7	6	101	26.3
Kenya	390	15	95.9	4	531	74.2
Indonesia	580	22	84.6	2	342	66.3
Egypt	690	45	19.0	7	69	35.1
Thailand	790	17	83.2	9	274	55.0
Phillipines	820	38	62.7	15	278	83.1
Zimbabwe	850	24	79.4	27	408	89.3
Nigiria	860	21	97.0	5	362	48.7
Ivory Coast	950	42	94.5	6	267	39.1
Jamaica	1330	48	1.4	17	135	80.1
Colombo	1460	65	86.3	31	575	106.8
Republic of Korea	1910	61	57.9	22	960	309.2
Chile	2210	82	43.3	26	193	75.7
Brazil	2240	69	61.1	36	233	71.5
Mexico	2270	68	14.3	35	177	94.1
Argentina	2520	83	19.9	47	340	171.5
Venezuela	4140	84	45.2	81	407	155.9
UK	9660	70	0.0	221	989	593.4
Japan	10080	78	0.0	129	550	330.0
France	11680	79	0.0	154	936	561.6
FRG	12460	85	0.0	211	1214	728.4
USA	13260	78	0.0	496	935	561.0

Source : [TERI, 1989]

Table 3.2. Correlation between GNP per capita and different parameters

Parameters	r
Useful energy per capita	0.94
Gross energy per capita	0.79
Urbanisation	0.67
Biofuels share	-0.74
Electricity per capita	0.88

Following observations can be made from Table 3.2

- A high correlation exists between useful[a] energy consumed per capita and GNP per capita. However, the correlation between gross energy use per capita and GNP per capita is low.
- The correlation between GNP per capita and the level of urbanisation is 0.67 indicating that to some extent, higher level of economic growth implies a higher level of urbanisation.
- Lesser developed countries depend predominantly on traditional energy sources (biofuels) as we obtained a negative correlation (-0.74) between biofuels share and GNP per capita.
- Correlation between electricity use per capita and GNP per capita is 0.88 indicating greater demand for electricity with rise in income.

3.3 The urban-rural difference in energy consumption

The kind of fuel used in Indian homes is strongly determined by, whether they are in rural or urban areas. Table 3.3 gives the estimates of monthly per capita consumption of different fuels in rural and urban households during 1977-78 based on the NCAER study [NCAER, 1985].

In 1977-78, urban households used 14 kg of biofuels per capita per month as compared to 29 kg in rural households.

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a The term "useful" energy refers to the amount consumed, net of conversion losses.

Table 3.3. Urban-rural differences in energy consumption : 1977-78

Fuel	Unit	Energy cons./ capita monthly		Per cent			
		Rural	Urban	Rural	Urban	Rural	Urban
Commercial				4.6	36.7	5.1	56.0
Soft coke	kg	0.19	2.61	1.0	17.4	3.1	23.2
Kerosene	kl	0.43	0.97	3.3	10.1	2.6	21.1
LPG	kg	neg	0.18	neg	2.5	neg	9.8
Electricity	kWh	0.41	2.92	0.3	3.0	0.4	1.9
Biofuels				95.4	67.0	94.9	44.0
Firewood	kg	13.17	9.73	54.4	53.6	59.2	35.5
Agrl.residue	kg	4.92	0.67	17.9	3.3	15.6	1.7
Dungcake	kg	11.08	3.00	23.1	8.4	20.1	4.5
Charcoal	kg	neg	0.30	neg	1.7	neg	2.3
Gross	MJ	481.90	360.48				
Useful	MJ	44.38	54.43				

neg denotes negligible
Source : [NCAER, 1985]

This is due to the substitution of commercial fuels like LPG and kerosene in urban areas for biofuels. Firewood, surprisingly, played an important role in household energy, even in urban areas. During 1977-78, firewood met more than half of the total gross energy needs of urban homes - about the same in rural areas.

In terms of gross energy, the per capita energy consumption in rural areas is 34 per cent higher, compared to that in urban areas (Table 3.3). This is because of the predominant use of traditional fuels (95 per cent of the total energy) in rural areas. We know that such fuels have low efficiency (10 per cent in wood burning chulhas compared to about 60 per cent in LPG stoves). On the other hand, in

terms of total useful energy, the per capita consumption in urban areas is 23 per cent higher, compared to that in rural areas.

3.3.1 Biomass - modern fuel transitions

During the period 1982-83 to 1987-88 the household sector has witnessed a steady shift from non-commercial to commercial sources of energy in urban as well as rural areas. The share of kerosene and LPG has increased, from 34.9 per cent to 44.5 per cent in the urban areas, and from 4.8 per cent to 9.9 per cent in the rural areas (Table 3.4).

Table 3.4. Percentage share of different forms of energy in urban and rural households

Fuel	Rural		Urban	
	1982-83	1987-88	1982-83	1987-88
A. Non-commercial	94.5	89.0	58.1	47.5
B. Commercial	5.5	11.0	41.9	52.5
Kerosene	4.0	8.7	26.5	31.9
LPG	0.8	1.2	8.4	12.6
Soft coke	0.7	1.1	7.0	8.0
C. Total	100.0	100.0	100.0	100.0

Source : [Oberoi, 1988].

3.3.2 Expenditure on Energy

In 1983, the average per capita monthly expenditure on energy in urban areas (Rs. 11.40) was 40 per cent higher than the corresponding expenditure in rural areas [NSSO, 1985]. However, the share of energy expenditure in total expenditure is about the same in rural and urban areas. The poor

households in urban areas spend much less on energy, but their expenditure share on energy accounts for a significant portion (14 per cent of the total household expenditure) as compared to the upper income group (4 to 6 per cent).

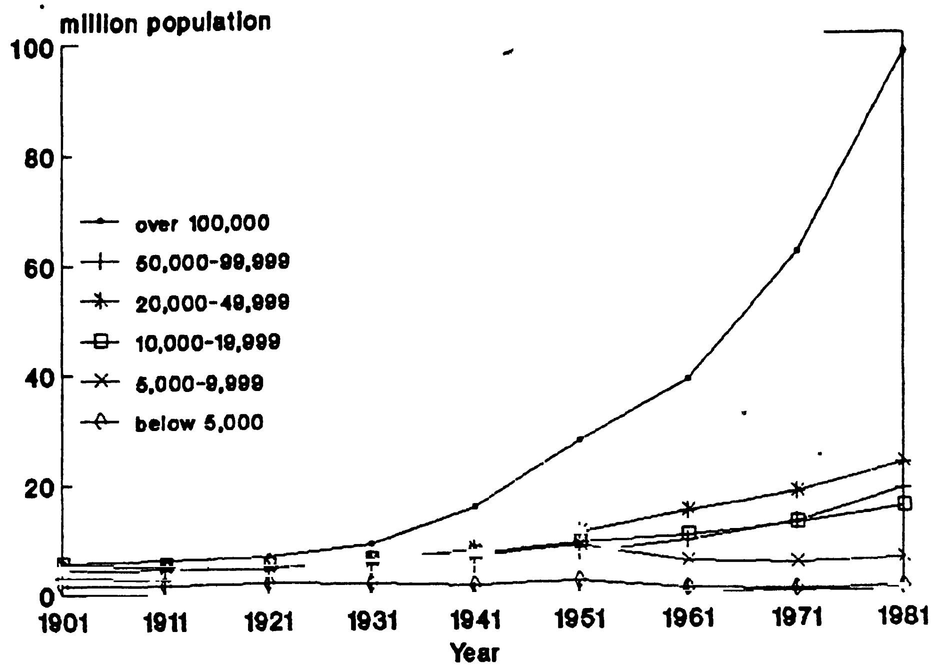
3.4 Urbanisation and household energy consumption

According to 1981 census, there were 3301 urban agglomerations in the country. The structure of India's urbanisation include 218 cities (populations exceeding 100,000), 1013 medium towns (population between 20,000 and 100,000) and 2070 small towns (population less than 20,000).

Over 60 per cent of India's urban population lives in 218 cities. Medium towns account for about one fourth of the urban population and the remaining 2076 small towns share less than 15 per cent of the urban population. Over this century, the structure of urbanisation has been changing significantly with increasing concentration towards larger cities as shown in Figure 3.1. Urban growth has occured mainly in the 'over-one-lakh' cities. Such concentration of population in the larger cities reflects a progressive shift in the pattern of urbanisation, which has been going on in India since 1901.

The pronounced urban population growth in the large cities as compared with the more evenly spread smaller towns also affect the rate of increase in energy consumption in

Fig.3.1: Urban population growth by city/town size



households. Table 3.5 presents share of energy use of different sizes of urban settlement. Usually, the larger the urban settlement, the more developed are the distribution and marketing systems of LPG and kerosene. At the same time, in smaller settlements biofuels may be more readily available.

Table 3.5. Household energy patterns and city size: 1978-79

Population (in thousand)	Per capita energy consumption (kgcr)	Percentage of fuel share							
		Electricity	Kerosene	LPG	Coke	Firewood	Biofuels	Commercial	Non-commercial
Over 500	(294)	13.5	28.9	15.6	17.3	17.7	7.4	75.4	24.6
200-500	(275)	9.4	28.6	3.0	14.2	20.7	14.4	66.2	33.8
100-200	(269)	9.2	19.8	7.2	21.3	29.6	12.9	57.5	42.5
50-100	(263)	8.0	18.7	6.4	22.5	31.8	12.6	55.6	44.4
20-50	(243)	6.3	9.5	2.9	18.8	38.6	23.9	37.6	62.5
Under 20	(243)	6.7	16.6	1.5	14.3	32.9	28.2	39.1	60.9

Source : [NCAER, 1985]

3.4.1 Fuel transition over time

In 1983-84, the NCAER conducted a large nationwide urban household survey comparable with its earlier, 1978-79 survey [Leach, 1987]. Considerable changes occurred in the mix of fuels in urban households for cooking and heating during this five-year interval, when kerosene and LPG generally became cheaper, compared with woodfuels. Table 3.6 summarizes these change.

Table 3.6. Fuel shares for cooking and heating by income

Energy source		Income groups (Rs. per annum per Household)					
		Upto 3000	3000-6000	6000-12000	12000-18000	Over 18000	All
Firewood	1979	60.0	40.0	25.1	17.4	12.1	42.4
	1984	53.5	30.8	17.9	9.9	9.6	27.4
Soft coke	1979	12.8	20.2	23.6	16.7	17.3	18.4
	1984	6.4	18.0	17.9	15.2	8.3	15.3
Kerosene	1979	13.2	21.3	21.5	22.0	18.9	18.7
	1984	23.8	36.9	40.2	38.2	32.8	35.7
LPG	1979	0.8	4.6	14.2	26.9	32.9	6.6
	1984	1.2	4.6	15.7	27.9	39.3	11.5
Others	1979	13.3	13.1	15.6	17.0	18.8	13.9
	1984	15.2	9.7	8.3	8.8	10.1	10.1
(Thousand households)	1979	(7286)	(9895)	(4792)	(611)	(524)	(23108)
	1984	(4885)	(9298)	(9742)	(2598)	(1193)	(27716)

Shares are on a coal replacement basis for cooking and heating
Source : [Leach, 1987]

The data from Table 3.6 reveals the following :

A substantial switch away from firewood, mostly to kerosene and bottled gas (LPG). In total, the firewood share fell from 42 per cent to 27 per cent, with every income group experiencing a drop. The fall was least for the lowest income group (11 per cent, from 60 to 3.5 per

cent), but was progressively greater for higher income ranges.

- Other fuels, which refer to crop residue and electricity, also dropped, as did soft coke. The substitute fuels were kerosene and LPG, whose shares roughly doubled : kerosene from 19 to 36 per cent and LPG from 6.6 to 11.5 per cent.
- Importance of kerosene increased quite evenly across all income groups, but LPG was mainly confined to the higher income range.
- There was a shift in the distribution of urban households across income groups, with increase in the share from middle to high income groups and decrease in the share of the lowest income group.

3.4.2. Kerosene versus LPG prices

An important reason for the increase in the consumption of kerosene and LPG in the household sector is subsidization of their prices. The kerosene used in the household sector is subsidized to the extent of Rs. 1232 per kilo litre. During 1989-90, the total amount of subsidy on this account was Rs. 1070 crores. It is also pertinent to note, that there is a price differential between the kerosene sold for cooking and lighting (Rs. 1937 per kilo litre ex-storage point), and industrial use (Rs. 3039 per kilo litre ex-storage point). Moreover, there is a significant price differential between kerosene on the one hand and high speed diesel and motor spirit on the other. These price differentials result in the diversion of kerosene from the household sector to the industrial sector, as also

adulteration of diesel oil and motor spirit in the transport sector.

LPG for domestic use is heavily subsidized. As in the case of kerosene, there is a price differential of LPG for different users. The price of LPG cylinders for domestic use is Rs. 3449 per metric tonne, for non-domestic users under essential categories Rs. 6151 per metric tonne, when sold in cylinders. These differentials also result in the diversion of LPG.

3.4.3 Increasing use of electrical appliances

Urban households consume energy for various end-uses like cooking, water heating, lighting, space heating, space cooling and 'others'. The 'others' category includes the use of electrical appliances like irons, washing machines, exhaust fans, refrigerators, water pumps, mixers/grinders and television sets that are not included under the specific end-uses mentioned above. Appliances which were considered expensive in the early seventies, are now available at affordable prices to consumers. The production of refrigerators has increased almost fivefold, that of fans and air-conditioners about four times and that of lamps about twice (Table 3.7).

Electricity use in urban areas is seven times greater than in rural areas [TERI, 1989], primarily because of higher household income and modernization. As mentioned earlier, in section 3.2, there is a positive correlation (0.67) between the level of urbanisation and per capita income of a country.

Table 3.7. Production of selected household appliances (thousands)

	1970	1975	1980	1983	1985	1986
Incandescent lamps	10300	12900	20100	27200	27100	28400
Fans	1570	1310	4120	4610	5200	4700
Refrigerators	65.4	108.9	278.0	465.2	677.6	591.4
Portable room air conditioners	17	9	26.2	26.9	31.0	39.5

Source : [CMIE, 1987]

The increase in household income leads to demand for new services such as refrigeration, air-conditioning, entertainment, etc. which have a major impact on domestic demand for electricity.

3.4.4 Energy use by the urban poor

The problems faced by urban poor households must be paid special attention. The energy consumption of the poor households is between 1256 and 2053 kJ per capita per day of 'useful energy'. This is much lower than the minimum requirements of 2847 kJ, worked out by the Advisory Board on Energy, Government of India [GOI, 1985]. In particular, the consumption for lighting is very low since a majority of them use kerosene lamps. Even in urban areas, poor households are heavily dependent on biofuels - mainly firewood, the price of which has increased steeply (nearly fourfold between 1983 and 1985).

3.4.5 Variations in energy use across cities/towns

We now look at the results of some recent studies carried out at the city/town level to supplement the findings

at the macro-level. Table 3.8 presents the variation in household energy consumption in different size cities.

Table 3.8. Household energy consumption in selected cities

Cities/towns	Population (thousand)	Useful annual per capita total energy consumption (MJ)	Annual per capita electricity consumption (kWh)
Delhi	5729	1193	612.0
Madras	4289	1137	340.0
Pune	1685	1008	129.6
Jaipur	1015	1010	330.0
Jabalpur	757	1083	256.0
Solapur	514	802	147.6
Nanded	191	788	98.4
Satara	84	922	117.6
Srirampur	55	842	110.4
Talegam	22	821	62.4
Junnar	18	1092	68.4

Source : [TERI, 1989]

One sees an annual variation from 788 MJ in Nanded to 1193 MJ in Delhi in terms of total per capita useful energy consumption in the domestic sector. Variation in electricity consumption is more striking ! A metropolitan city like Delhi consumes 612 kWh per capita annually - nearly ten times the level in a small town like Talegam and Junnar.

3.5 Analysis of TERI survey results

The ever increasing urban population, whose share in total population by turn of this century is expected to be

around 32 per cent, as well as changing pattern of urban growth, prompted TERI, to carry out a survey based analysis of energy consumption in urban households spread over different regions of the country, during 1987 [TERI, 1988].

a. Survey design

The urban areas of the country were broadly divided into three categories by density of population - class I (large) cities, with a population of 100,000 and above, class II and III (medium) towns together, with a population between 20,000 and 99,999 and class IV, V and VI (small) towns together, with a population less than 20,000. It was proposed to cover approximately a thousand households, divided into 10 cities. On the basis of the population distribution between the above three class cities, urban household energy surveys were carried out in 2 large size cities, 3 medium size and 5 small size towns - with a sample distribution of 150 households each in large cities, 100 households each in medium towns and 75 households each in small towns. Further, different areas within these cities were identified as representative of different income classes. To have a better geographical coverage the sample within each city class was broken down into different areas on the basis of income distribution of the city population. Areas were identified on the basis of relatively homogeneous socio-economic characteristics. Table 3.9 gives the number of urban households that were surveyed in the different income classes.

Table.3.9. Distribution of urban households surveyed in different income classes by region during 1987

(No. of households)

Income class (in Rupees)	Region					
	North	West	South	East	Central	All-India
Upto 500	9 (4.0)	6 (3.4)	3 (1.3)	11 (6.3)	9 (5.6)	37 (3.8)
500-1000	18 (8.0)	24 (13.6)	27 (12.0)	31 (17.7)	41 (25.6)	141 (14.7)
1000-1500	21 (9.3)	26 (14.7)	33 (14.7)	51 (29.1)	29 (18.1)	160 (16.6)
1500-3000	79 (35.1)	78 (44.1)	105 (46.7)	66 (37.7)	52 (32.5)	380 (39.5)
3000-4500	42 (18.7)	20 (11.3)	41 (18.2)	16 (9.1)	14 (8.8)	133 (13.8)
4500-6000	32 (14.2)	17 (9.6)	9 (4.0)	a	5 (3.1)	63 (6.5)
Over 6000	24 (10.7)	6 (3.4)	7 (3.1)	a	10 (6.3)	48 (5.0)
All together	225 (100)	177 (100)	225 (100)	175 (100)	160 (100)	962 (100)

Note : Figures in parentheses denote percentage distribution of households

a no households were found in this income class.

b. Data collection method

Households in the identified areas were randomly surveyed using a pre-tested household questionnaire. Method of recall was used for collecting the relevant information.

The household questionnaire comprised of five sections. The first section collected general information on factors such as size of the dwelling, family size, income etc. The second section dealt with use of different types of fuels (other than electricity) for cooking, water heating and lighting. The last three sections dealt with electrical

appliances used in different seasons. In these sections information was collected on (i) summer gadgets, (ii) winter gadgets and (iii) all other appliances used throughout the year.

The data collected at the household level was compiled and entered in an IBM-AT computer system using LOTUS 123 software.

c. Database for analysis

To develop an urban household energy data base, the results of the 1987 household survey were compiled for the five different regions viz., North, South, East, West and Central[a]. For each region the database is analysed further for different income classes, as survey results have shown that with rise in income, the per capita energy goes up. While data on income was collected by 13 different income groups these were later aggregated into 7 income classes viz., monthly household income less than Rs. 500, Rs. 500-1000, Rs. 1000-1500, Rs. 1500-3000, Rs. 3000-4500, Rs. 4500-6000 and over Rs. 6000.

The subsequent sections highlight the analysis of TERI survey results with the following objectives :

1. to assess the impact of increasing incomes on energy demand;

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a In all, 10 cities were surveyed. Delhi and Sahibabad in North, Jaipur and Sanganer in West, Madras and Tambaram in South, Chandwar and Baranga in East and Jabalpur and Nainpur in Central region of India.

2. to study the mix of fuels consumed across different income classes and also in different regions;
3. to study the seasonal variations in energy consumption across different regions;
4. to estimate energy consumption by end-use;
5. to study the ownership of electrical appliances across different regions;
6. to extrapolate urban household energy demand by fuels, across different income categories, for the periods 1991 and 2001.

3.5.1 Expenditure on energy

Table 3.10 provides approximations as to the percentage of income that is spent on energy by the different income classes in all the 10 cities surveyed.

Table 3.10. Per cent of income spent on energy in different income classes for 10 cities

Region	City	Monthly household income class (Rs.)				
		Upto 500	500-1000	1000-1500	1500-3000	Over 3000
North	Delhi	37.10	13.06	7.52	6.87	6.76
	Sahibabad	11.73	10.77	5.93	5.52	3.46
West	Jaipur	39.52	20.05	14.68	9.20	5.44
	Sanganer	37.00	24.35	14.57	10.35	7.01
South	Madras	34.07	19.91	12.32	6.46	5.60
	Tambaram	30.07	14.06	7.35	5.57	4.09
East	Choudwar	38.37	17.63	10.30	7.13	5.00
	Baranga	19.50	12.34	9.78	8.60	4.61
Central	Jabalpur	33.45	8.82	10.16	5.35	4.64
	Nainpur	27.14	17.56	13.98	8.75	4.35

It is seen from Table 3.10 that progressively lower shares of income are spent on energy with increase in income. Thus, it is the lowest income class (below Rs. 500 per month) that would be affected most with any energy price changes as between 30 and 40 per cent of their income is spent on meeting basic energy required for cooking and to a small extent water heating and lighting. The second income class on an average spends between 10 and 20 per cent of its income on energy, whereas the third, fourth and fifth income class spends about 15 per cent, 10 per cent and 5 per cent income on energy respectively.

Paradoxically, while the lowest income class spends a large part of its income on energy, the useful energy that they get out of this, is much lower than that in the higher income classes. In other words, the disparity in percentage of income spent on meeting energy requirements would be accentuated if one were to take into account the relative efficiencies of the fuels being consumed.

3.5.2 Impact of seasonality

LPG, kerosene, soft coke, firewood and dungcake are used almost exclusively for the end-uses like cooking and water heating whereas electricity is used for lighting, space cooling, space heating and to a certain extent for cooking water heating and others.

Table 3.11 presents the variation in monthly fuel consumption in summer and winter months (among the households using these fuel) across different income categories :

Table 3.11. Per capita monthly consumption of different fuels by income categories in summer and winter months - All India Urban

Income class in Rupees	LPG (kg)		Kerosene (l)		Soft coke (kg)		Firewood (kg)		Dungcake (kg)		Electricity (kWh)	
	Summer	Winter	Summer	Winter	Summer	Winter	Summer	Winter	Summer	Winter	Summer	Winter
0-500	3.34	3.55	2.18	2.39	4.74	5.11	18.8	22.15	13.35	17.37	10.42	7.79
	(2.52)	(2.86)	(1.94)	(2.51)	(3.80)	(3.71)	(16.05)	(21.29)	(8.27)	(12.85)	(11.78)	(9.25)
500-1000	3.53	3.57	2.57	2.73	13.56	12.23	25.33	28.19	14.72	14.51	11.17	8.27
	(1.53)	(1.57)	(2.40)	(2.48)	(11.16)	(12.91)	(29.21)	(36.19)	(12.24)	(12.27)	(10.43)	(8.31)
1000-1500	3.23	3.33	2.00	2.30	13.79	15.42	22.39	23.08	16.96	18.82	15.13	11.40
	(1.57)	(1.57)	(1.79)	(2.04)	(34.77)	(34.81)	(25.07)	(25.44)	(21.57)	(23.97)	(11.15)	(9.53)
1500-3000	3.26	3.54	1.87	2.07	7.50	6.71	15.95	16.49	14.07	12.67	26.61	20.97
	(1.59)	(1.94)	(1.92)	(2.15)	(5.50)	(5.69)	(16.11)	(16.35)	(13.36)	(12.80)	(23.07)	(21.29)
3000-4500	3.67	3.93	1.06	1.26	2.17	2.53	16.86	18.20	3.35	3.35	39.50	30.29
	(2.27)	(2.53)	(0.67)	(1.05)	(2.71)	(3.40)	(14.51)	(14.34)	(0.32)	(0.32)	(38.61)	(34.38)
4500-6000	3.40	4.78	1.31	1.49	5.00	5.00	13.49	16.36	100.00	108.33	45.13	35.64
	(1.58)	(9.36)	(0.98)	(1.04)	-	-	(9.07)	(11.36)	-	-	(39.15)	(32.02)
Over 6000	3.95	3.99	0.93	1.26	-	-	9.28	8.08	-	-	70.55	67.38
	(2.43)	(2.51)	(0.60)	(0.86)			(9.95)	(8.42)	-		(85.18)	(103.72)
All together	3.42	3.74	1.90	2.13	9.70	10.03	20.15	21.49	16.30	17.52	27.23	21.81
	(1.81)	(3.49)	(1.89)	(2.11)	(19.07)	(19.96)	(22.45)	(25.33)	(19.13)	(21.09)	(33.64)	(34.04)

Figures in parentheses denote standard deviation.

The percentage distribution of households using different fuels across different income categories (separately for summer and winter months) are presented in Table 3.12.

Excepting electricity, per capita consumption of all other fuels is higher in winter months than in summer, mainly due to hot water requirement in winter season. Whereas, electricity consumption in summer is nearly 25 per cent higher than in winter (Table 3.11) due to higher demand for

Table 3.12. Percentage distribution of households using aspecific fuel by income classes in summer and winter
All India Urban

Income class in Rupees	LPG		Kerosene		Soft coke		Firewood		Dungcake		Electricity	
	Summer	Winter	Summer	Winter	Summer	Winter	Summer	Winter	Summer	Winter	Summer	Winter
0-500	13.5	10.8	70.3	67.6	10.8	10.8	54.1	51.4	27.0	24.3	89.2	86.5
500-1000	29.1	28.4	47.5	63.8	7.8	9.9	35.5	35.5	13.5	13.5	94.3	93.6
1000-1500	46.3	46.8	68.8	70.0	11.25	11.25	40.0	33.1	14.4	14.4	98.8	98.1
1500-3000	73.9	74.5	54.7	57.4	7.4	5.8	16.6	17.4	1.6	1.8	99.2	99.2
3000-4500	95.5	95.5	39.1	38.4	3.0	3.0	5.3	5.3	1.5	1.5	100.0	100.0
4500-6000	95.2	95.2	30.0	33.3	1.7	1.7	8.3	8.3	1.7	1.7	100.0	100.0
Over 6000	97.9	97.9	29.2	22.9	-	-	6.3	8.3	-	-	100.0	100.0
All together	66.0	66.1	53.5	54.8	6.9	6.6	20.9	21.2	6.3	6.3	98.2	97.9

space cooling in summer months. Also, with rise in income the consumption level shows a rising trend.

It can be seen from Table 3.12, dependence on kerosene and biofuels is higher in the lower income classes. At an aggregate level, nearly 66 per cent of the urban households use LPG, 54 per cent kerosene, 7 per cent soft coke, 21 per cent firewood, 6 per cent dungcake and 98 per cent electricity to meet the domestic energy requirement.

3.5.3 Fuel mix pattern

During the household survey fuel consumption figures were recorded in physical units such as kg or litres. Since a common unit is needed to compare different fuels, energy units are used here, based on calorific values. The calorific values employed for different fuels are presented in Table 3.13.

Table 3.13. Energy conversion norms

	Unit	kJ/unit
LPG	kg	45217
Kerosene	l	35785
Soft coke	kg	20934
Firewood	kg	19750
Dungcake	kg	8918
Electricity	kWh	3600

Source : [NCAER, 1985]

Table 3.14 presents the mix of per capita total fuels consumed in urban households across different income categories. LPG and electricity consumption is seen to increase rapidly with an increase in income. Between the lowest (upto Rs. 500 per month per household) and the highest income (over 6000 per month per household) category the difference in LPG and electricity consumption is nearly ninefold. Contrast, the consumption level of firewood and dungcake goes down with increase in income level. However, in the case of kerosene and soft coke, the consumption level goes up from the lowest to the next income category and thereafter there is a fall with further rise in income level. Thus, with rising income, urban families are able to switch from biofuels to more efficient, convenient and cleaner modern fuels. The income threshold at which these switches occur - usually in two steps, from biofuels to kerosene and then to LPG (or electricity) - is an important policy matter.

Table 3.14. Per capita annual consumption of different fuels by income classes
All India Urban

Income class in Rupees	LPG	Kerosene	Soft coke	Firewood	Dungcake	Electricity	All together Gross	All together Useful	Efficiency of utilization (%)
Upto 500	227 (5.2)	675 (15.3)	134 (3.0)	2552 (57.8)	419 (9.5)	405 (9.2)	4412 (100)	1313	(30)
500-1000	553 (12.4)	715 (15.9)	286 (6.4)	2249 (50.3)	211 (4.7)	460 (10.3)	4474 (100)	1547	(35)
1000-1500	828 (17.9)	642 (13.9)	413 (8.9)	1801 (38.9)	275 (5.9)	669 (14.5)	4628 (100)	1855	(40)
1500-3000	1370 (35.7)	474 (12.4)	118 (3.1)	653 (17.0)	24 (.6)	1196 (31.2)	3835 (100)	2373	(62)
3000-4500	1970 (46.7)	193 (4.6)	18 (.4)	219 (5.2)	5 (.1)	1817 (43.0)	4222 (100)	3130	(74)
4500-6000	2113 (43.6)	182 (3.8)	20 (.4)	281 (5.8)	177 (3.6)	2071 (42.8)	4844 (100)	3494	(72)
Over 6000	2111 (35.1)	120 (2.0)	-	149 (2.5)	-	3635 (60.4)	6015 (100)	4982	(83)
All together	1285 (29.8)	469 (10.9)	166 (3.8)	1041 (24.2)	115 (2.7)	1235 (28.6)	4311 (100)	2433	(56)

Figures in parentheses denote percentage values.

The percentage contribution of LPG to total energy consumption is found to increase significantly from approximately 5 per cent in the lowest income class to about 35 per cent in the highest income category. Kerosene consumption goes up from about 15 per cent to 16 per cent in the first two income categories and thereafter its share goes down to around 2 per cent in the highest income class. Share of soft coke goes up in the first three income classes from 3 per cent to about 9 per cent and then goes down in rest of the higher income classes. Firewood consumption drops

drastically from about 58 per cent to about 3 per cent with increase in income level. Share of electricity rises steeply from about 9 per cent in the lowest income class to nearly 60 per cent in the highest income category. Consumption of dungcake declines significantly with rise in income level.

Table 3.14 also presents survey results on per capita energy consumption keeping in mind the differences between gross and useful energy consumption. It may be observed that the trend in per capita annual useful energy consumption becomes more pronounced with rise in income level, whereas this is not so for gross energy consumption. Thus, while the ratio of useful to gross cooking energy consumption in the lowest income class is as low as 30 per cent, this ratio in the highest income class is nearly 83 per cent. This reflects a shift from biofuels to more efficient fuels such as kerosene, LPG and electricity with rise in the income level.

3.5.4 Regional variations

Tables 3.15 to 3.19 present per capita fuel consumption in different regions across various income categories. In all the five regions energy consumption is seen to increase with rise in income level. Per capita annual useful energy consumption is found out to be maximum (3659 MJ) in the Northern region, followed by Western region (2246 MJ), Central region (2243 MJ) and Southern region (2221 MJ). In the case of Eastern region, the consumption level went down

to 1494 MJ as no households were surveyed in the last two (higher) income classes.

Table 3.15. Per capita annual consumption of different fuels by income classes
Region : North

(MJ)

Income class in Rupees	LPG	Kerosene	Soft coke	Firewood	Dungcake	Electricity	All together Gross	All together Useful	Efficiency of utilization (%)
Upto 500	75 (2.3)	1778 (54.2)	279 (8.5)	2742 (8.3)	297 (8.9)	588 (17.8)	3301 (100)	1657	(50)
500-1000	612 (14.3)	985 (23.0)	1076 (25.1)	49 (1.2)	818 (19.1)	739 (17.3)	4279 (100)	1919	(45)
1000-1500	693 (15.6)	1208 (27.2)	624 (14.0)	101 (2.2)	1187 (26.7)	634 (14.3)	4447 (100)	1935	(43)
1500-3000	1934 (46.3)	419 (10.0)	50 (1.2)	31 (.7)	36 (.9)	1707 (40.9)	4177 (100)	3096	(74)
3000-4500	2477 (46.2)	132 (2.5)	-	-	8 (.1)	2748 (51.2)	5365 (100)	4301	(80)
4500-6000	2058 (41.3)	92 (1.8)	39 (.8)	-	-	2797 (56.1)	4986 (100)	4086	(82)
Over 6000	2627 (31.1)	40 (.5)	-	-	-	5786 (68.4)	8453 (100)	7382	(87)
All together	1831 (36.8)	452 (9.1)	178 (3.6)	35 (.7)	202 (4.1)	2270 (45.7)	4968 (100)	3659	(74)

Figures in parentheses denote percentage values.

Table 3.16. Per capita annual consumption of different fuels by income classes
Region : West

(MJ)

Income class in Rupees	LPG	Kerosene	Soft coke	Firewood	Dungcake	Electricity	All together Gross	All together Useful	Efficiency of utilization (%)
Upto 500	170 (5.7)	370 (12.4)	-	1949 (65.4)	-	493 (16.5)	2982 (100)	1053	(35)
500-1000	336 (9.7)	1116 (32.3)	99 (2.9)	1127 (32.7)	96 (2.8)	676 (19.6)	3450 (100)	1625	(47)
1000-1500	1246 (37.1)	241 (7.2)	24 (.7)	773 (23.0)	-	1072 (32.0)	3356 (100)	2053	(61)
1500-3000	996 (27.5)	434 (12.0)	53 (1.5)	675 (18.7)	55 (1.5)	1406 (38.8)	3619 (100)	2332	(64)
3000-4500	1875 (48.0)	18 (.5)	-	190 (4.9)	-	1819 (46.6)	3902 (100)	2980	(76)
4500-6000	1365 (31.5)	343 (7.9)	-	637 (14.7)	656 (15.1)	1334 (30.8)	4335 (100)	2492	(57)
Over 6000	1190 (31.1)	337 (8.8)	-	790 (20.6)	-	1511 (39.5)	3828 (100)	2504	(65)
All together	1057 (29.0)	437 (12.0)	41 (1.1)	739 (20.3)	100 (2.7)	1270 (34.9)	3644 (100)	2246	(62)

Figures in parentheses denote percentage values.

Table 3.17. Per capita annual consumption of different fuels by income classes
Region : South

(MJ)

Income class in Rupees	LPG	Kerosene	Soft coke	Firewood	Dungcake	Electricity	All together Gross	All together Useful	Efficiency of utilization (%)
Upto 500	678 (21.9)	532 (17.2)	84 (2.7)	1287 (41.6)	306 (10.0)	204 (6.6)	3091 (100)	1111	(36)
500-1000	1383 (36.4)	986 (26)	8 (.2)	631 (16.6)	299 (7.9)	488 (12.9)	3795 (100)	1937	(51)
1000-1500	1390 (44.2)	849 (26.9)	2 (.1)	172 (5.5)	16 (.5)	718 (22.8)	3147 (100)	2003	(64)
1500-3000	1710 (51.6)	488 (14.7)	23 (.7)	79 (2.4)	3 (.1)	1011 (30.5)	3314 (100)	2297	(69)
3000-4500	1841 (55.0)	254 (7.6)	2 (.1)	95 (2.8)	9 (.3)	1145 (34.2)	3346 (100)	2391	(71)
4500-6000	1672 (57.8)	171 (5.9)	-	-	-	1050 (36.3)	2893 (100)	2139	(74)
Over 6000	2557 (66.2)	118 (3.1)	-	17 (.4)	-	1170 (30.3)	3862 (100)	2766	(72)
All together	1659 (49.5)	534 (15.9)	13 (.4)	173 (5.2)	46 (1.4)	926 (27.6)	3351 (100)	2221	(66)

Figures in parentheses denote percentage values.

Table 3.18. Per capita annual consumption of different fuels by income classes
Region : East

(MJ)

Income class in Rupees	LPG	Kerosene	Soft coke	Firewood	Dungcake	Electricity	All together Gross	All together Useful	Efficiency of utilization (%)
Upto 500	-	267 (8.1)	-	2141 (65.1)	737 (22.5)	142 (4.3)	3287 (100)	664	(20)
500-1000	184 (8.4)	185 (8.5)	186 (8.5)	1220 (56.0)	119 (5.5)	285 (13.1)	2179 (100)	710	(32)
1000-1500	289 (6.7)	444 (10.3)	798 (18.6)	1875 (43.6)	364 (8.5)	528 (12.3)	4298 (100)	1389	(32)
1500-3000	522 (12.7)	550 (13.3)	368 (8.9)	2000 (48.4)	16 (.4)	675 (16.3)	4131 (100)	1619	(39)
3000-4500	1279 (32.5)	231 (5.9)	-	931 (23.7)	-	1493 (37.9)	3934 (100)	2506	(64)
4500-6000	-	-	-	-	-	-	-	-	-
Over 6000[a]	-	-	-	-	-	-	-	-	-
All together[a]	431 (9.9)	409 (9.4)	404 (9.3)	2317 (53.4)	175 (4.0)	605 (14.0)	4341 (100)	1494	(34)

Figures in parentheses denote percentage values.

a No households were found in this income bracket

Table 3.19. Per capita annual consumption of different fuels by income classes
Region : Central

(MJ)

Income class in Rupees	LPG	Kerosene	Soft coke	Firewood	Dungcake	Electricity	All together Gross	All together Useful	Efficiency of utilization (%)
Upto 500	517	266	243	6112	505	520	8163	1928	(24)
	(6.3)	(3.3)	(2.9)	(74.9)	(6.2)	(6.4)	(100)		
500-1000	387	583	306	5716	23	325	7340	1713	(23)
	(5.3)	(7.9)	(4.2)	(77.9)	(.3)	(4.4)	(100)		
1000-1500	861	702	399	2162	-	524	4648	1774	(38)
	(18.5)	(15.1)	(8.6)	(46.5)		(11.3)	(100)		
1500-3000	1462	493	196	1015	13	1140	4319	2447	(57)
	(33.9)	(11.4)	(4.5)	(23.5)	(.3)	(26.4)	(100)		
3000-4500	1749	402	164	466	-	1359	4140	2707	(65)
	(42.2)	(9.7)	(4.0)	(11.3)		(32.8)	(100)		
4500-6000	5804	233	-	1372	-	1778	9187	5569	(61)
	(63.2)	(2.5)		(14.9)		(19.4)	(100)		
Over 6000	1324	130	-	49	-	1816	3319	2682	(81)
	(39.9)	(3.9)		(1.5)		(54.7)	(100)		
All together	1177	503	242	2617	39	866	5444	2243	(41)
	(21.6)	(9.2)	(4.5)	(48.1)	(.7)	(15.9)	(100)		

Figures in parentheses denote percentage values.

water heating. Consumption share of LPG is highest (47 per cent) for cooking, followed by firewood (32 per cent), kerosene (13 per cent), soft coke (5 per cent), dungcake (3 per cent) and electricity (less than 1 per cent).

Table 3.21. Percentage share of fuel mix pattern for different end-uses - **All India Urban**

Income class in Rs.	Cooking	Water heating	Lighting	Space heating	Space cooling	Others
LPG	47.07	11.60	-	-	-	-
Kerosene	12.55	23.21	7.90	-	-	-
Soft coke	5.01	3.27	-	-	-	-
Firewood	31.55	33.93	-	-	-	-
Dungcake	3.21	4.46	-	-	-	-
Electricity	0.51	23.50	92.10	100.00	100.00	100.00

However, in the case of water heating, firewood share is maximum (34 per cent), followed by kerosene and electricity (each 23 per cent), LPG (12 per cent), dungcake (5 per cent) and soft coke (3 per cent). Some portion of kerosene is also found to be used, among poor households, to meet their lighting demand.

Finally, in Table 3.22, information is provided on share of a specific fuel consumption among different end-uses. LPG, soft coke, firewood and dungcake are used to meet both cooking and water heating demands. Kerosene is used for cooking, water heating and lighting purposes and electricity is used for all types of end-uses.

Table 3.22. Percentage share of energy consumption across different end-uses - **All India Urban**

Income class in Rupees	Cooking	Water heating	Lighting	Space cooling	Space heating	Others
LPG	96.29	3.71	-	-	-	-
Kerosene	71.24	20.58	8.18	-	-	-
Soft coke	90.76	9.24	-	-	-	-
Firewood	85.62	14.38	-	-	-	-
Dungcake	82.14	17.86	-	-	-	-
Electricity	1.00	7.60	34.69	25.27	3.79	27.60

3.5.6 Electricity consumption

Per capita electricity consumption goes up with increase in the per capita income level. The level of correlation between them is as high as 0.68. Per capita annual electricity consumption in urban households is estimated to be 343 kWh (Table 3.23) and varies significantly across different regions. Per capita electricity consumption per year is found out to be the highest (631 kWh) in the Northern region, followed by 353 kWh in Western region, 257 kWh in Southern region, 241 kWh in Central region and the least being found to be 168 kWh in the Eastern region. Share of electricity consumption among different electrical appliances is also provided in Table 3.23.

By clubbing data for all the households, it is found that maximum contribution to electricity share is due to incandescent bulb (24 per cent), followed by ceiling fan (20 per cent), refrigerator (11 per cent) and the rest is shared

by all other appliances. But, there exist a large regional variation in the share of electricity consumption due to different electrical appliances and this is provided in Table 3.23.

Table 3.23. Electricity consumption share (%) by different electrical gadgets across different regions

	Regions					
	North	West	South	East	Central	All-India
Per capita annual electricity consumption	(631)	(353)	(257)	(168)	(241)	(343)
Summer gadgets						
Ceiling fan	16.7	14.5	26.3	28.7	19.1	19.5
Table fan	0.7	1.3	0.7	4.1	2.2	1.4
Air conditioner	2.0	-	4.4	2.1	0.7	1.9
Air cooler	2.8	3.1	-	-	2.5	2.0
Winter gadgets						
Immersion rod	3.6	1.3	1.1	-	2.1	2.1
Room heater	4.6	1.9	-	-	1.7	2.4
Coil heater	0.5	0.1	0.1	3.9	0.04	0.6
All season gadets						
Hot plate	0.7	0.1	0.4	1.2	1.3	0.7
Cooking range	0.5	0.3	0.4	-	0.6	0.4
Washing machine	0.8	0.6	0.1	0.1	0.1	0.5
Iron	4.0	13.9	5.5	16.8	12.5	8.7
Fluorescent tube	7.6	10.6	13.2	3.6	16.0	9.9
Incandescent bulb	21.3	40.5	15.4	17.1	20.8	23.8
Exhaust fan	0.2	0.1	0.2	-	0.03	0.1
Refrigerator	13.0	6.6	17.2	7.5	7.2	11.1
Television (B&W)	1.4	3.2	3.4	6.3	3.2	2.8
Television (colour)	1.1	0.4	2.8	1.3	0.6	1.2
Instant geyser	17.3	0.01	5.8	-	8.3	8.7
Video cassette player	0.3	0.1	0.9	-	0.01	0.3
Audio cassette player	0.3	0.7	1.2	0.9	0.4	0.6
Radio	0.4	1.1	0.9	6.2	0.6	1.2
Transister	0.1	0.04	0.1	0.1	0.1	0.1

Figures in parentheses denote kWh.

Finally, Table 3.24 presents appliance ownership pattern across different regions. By pooling all data points, it is estimated that nearly 8 per cent of the urban

households do not use incandescent bulbs. Similarly, nearly 14 per cent of the households do not have ceiling fans, 15 per cent of the households have no fluorescent bulbs so on and so forth.

There does exist a large variation in number of appliances (of different type) owned by each household in different regions, which can be studied in detail from Table 3.24.

3.6 Energy demand projections

Total household energy demand is estimated for the years 1991 and 2001 by adding up the gross product of total per capita fuel consumption in different income classes (obtained from TERI survey estimates) with the corresponding share of population belonging to each income group.

Distribution of urban population (excluding slum population)[a] across different income categories is worked out on the basis of the population distribution over various expenditure categories for the year 1986-87 [NSSO, 1989] and the savings rate in the corresponding expenditure classes [NCAER, 1985].

According to our estimates, nearly 50 per cent of the total urban population belongs to the first two lower income

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a The estimates of India's urban population living in slums vary. Nearly 30 per cent of the urban population are residing in slum areas and are therefore excluded from the total urban population for our present analysis [NIUA, 1988].

Table 3.24. No.of electrical appliances in use for urban households across regions

Appliances	North Avg.	North St.dev.	North %hhs	West Avg.	West St.dev.	West %hhs	South Avg.	South St.dev.	South %hhs
Summer gadgets									
Ceiling fan	3.79	2.10	95.1	2.51	1.47	85.9	3.32	1.74	95.6
Table fan	1.43	1.03	38.7	1.20	0.50	53.1	1.07	0.26	32.0
Air cond.	1.42	0.65	10.7	-	-	-	1.12	0.49	7.6
Air cooler	1.36	0.62	56.9	1.35	0.92	24.3	-	-	-
Winter gadgets									
Immersion rod	1.02	0.13	25.3	1.13	0.46	12.9	1.00	0.00	11.6
Room heater	1.42	0.94	29.8	1.41	0.73	12.4	-	-	-
Coil heater	1.13	0.35	6.7	1.00	0.00	1.12	1.00	0.00	4.0
All season gadets									
Hot plate	1.00	0.00	6.2	1.00	0.00	1.12	1.00	0.00	2.2
Cooking range	1.08	0.29	5.3	1.00	0.00	1.70	1.00	0.00	1.3
Washing machine	1.00	0.00	32.4	1.00	0.00	5.1	1.00	0.00	4.4
Iron	1.04	0.21	70.2	1.15	0.42	77.4	1.03	0.18	54.7
Fluo. tube	3.69	2.71	88.4	2.74	2.54	85.3	3.50	2.43	92.0
Incan. bulb	8.18	7.88	93.3	5.81	3.48	93.2	6.55	4.19	93.8
Exhaust fan	1.29	0.46	10.7	1.67	1.15	1.70	1.50	0.87	4.4
Refrigerator	1.07	0.28	71.6	1.02	0.14	27.1	1.00	0.00	48.4
TV (B&W)	1.02	0.13	54.2	1.02	0.13	68.9	1.00	0.00	46.2
TV (colour)	1.01	0.11	37.3	1.12	0.49	9.6	1.00	0.00	37.3
Instant geyser	1.31	0.69	34.2	1.33	0.82	3.4	1.13	0.33	17.8
VCR	1.00	0.00	14.2	1.50	1.00	2.3	1.00	0.00	13.3
Audio cassette	1.07	0.26	31.6	1.21	0.54	19.2	1.00	0.19	60.0
Radio	1.08	0.28	32.4	1.07	0.31	38.9	1.03	0.17	30.2
Transister	1.09	0.28	41.3	1.00	0.00	17.5	1.02	0.14	23.6

Table 3.24 contd..

Appliances	East Avg.	East St.dev.	East %hhs	Central Avg.	Central St.dev.	Central %hhs	All India Avg.	All India St.dev.	All India %hhs
Summer gadgets									
Ceiling fan	2.26	1.35	72.6	3.06	2.49	76.3	3.09	1.95	86.3
Table fan	1.24	0.51	60.6	1.34	0.73	66.3	1.27	0.68	49.4
Air cond.	1.00	0.0	1.7	1.00	0.0	1.25	1.26	0.57	4.8
Air cooler	1.00	0.0	1.1	1.28	0.7	18.13	1.34	0.70	20.9
Winter gadgets									
Immersion rod	1.00	0.00	3.4	1.00	0.00	13.8	1.03	0.21	13.9
Room heater	1.00	0.00	3.4	1.50	0.82	10.0	1.41	0.86	11.5
Coil heater	1.04	0.2	43.4	1.00	0.00	1.9	1.05	0.21	10.9
All season gadets									
Hot plate	1.00	0.00	0.57	1.00	0.00	1.8	1.00	0.00	2.6
Cooking range	-	-	-	1.00	0.00	1.3	1.05	0.22	2.1
Washing machine	1.25	0.5	2.3	1.00	0.00	3.1	1.01	0.10	10.5
Iron	1.03	0.16	68.0	1.05	0.22	59.4	1.06	0.26	65.7
Fluo. tube	2.01	0.84	74.9	3.98	3.84	80.0	3.24	2.71	84.8
Incan. bulb	4.89	1.96	91.4	4.84	4.68	85.6	6.23	5.18	91.8
Exhaust fan	-	-	-	1.00	0.00	1.9	1.35	0.66	4.2
Refrigerator	1.00	0.00	17.1	1.00	0.00	21.9	1.03	0.19	39.8
TV (B&W)	1.00	0.00	44.0	1.02	0.15	52.5	1.01	0.11	52.9
TV (colour)	1.00	0.00	9.1	1.00	0.00	11.25	1.01	0.15	22.8
Instant geyser	-	-	-	1.31	0.63	8.13	1.26	0.61	14.1
VCR	-	-	-	1.00	0.00	0.63	1.03	0.24	6.9
Audio cassette	1.00	0.00	21.7	1.13	0.34	38.13	1.07	0.28	35.2
Radio	1.02	0.18	80.6	1.10	0.39	41.9	1.08	0.27	43.5
Transister	1.00	0.00	11.4	1.13	0.34	37.5	1.07	0.25	26.7

categories - with 3 per cent belonging to lowest income group and the balance 47 per cent in the next higher income category. In the remaining half - 28 per cent households have income between Rs. 1000 and Rs. 1500 and 22 per cent with an income over Rs. 1500.

The total urban population (excluding slum) during 1991 is estimated as 161 million whereas in 2001 it would be 228 million [NIUA, 1988]. The distribution of this total population in the four income categories is also worked out on the basis of its percentage share as shown in Table 3.25. The same table also provides the per capita fuel consumption annually in the different income categories. On multiplying the per capita energy consumption norms with the population figures for 1991 and 2001 in different income classes, household energy demand (by fuel type) is obtained for the corresponding income category (Table 3.25).

It can be observed that total LPG demand during 1991 is estimated to be 3.07 mt and that in 2001, it is likely to further go up to 4.35 mt. For kerosene the corresponding figures are 2.15 mt and 3.05 mt respectively. Similarly for soft coke - 2.08 mt and 2.94 mt, firewood - 14.16 mt and 20.07 mt, dungcake - 3.51 mt and 4.97 mt. In the case of electricity, demand for 1991 is estimated to be 34.57 tWh and that for 2001 it is 49.00 tWh.

Table 3.25. Energy demand projections in urban households

Income class in Rupees	Distribution of households (%)	All India urban population - excluding slums (million) 1991	2001	Annual per capit consumption norms LPG (kg)	Kerosene (kg)	Soft coke (kg)	Firewood (kg)	Dungcake (kg)	Electricity (kWh)
Upto 500	2.54	4.09	5.80	5.01	14.71	6.39	129.23	47.01	112.39
500-1000	47.44	76.38	108.26	12.24	15.58	13.64	113.88	23.64	127.78
1000-1500	27.58	44.40	62.94	18.32	13.98	19.72	91.21	30.86	185.81
Over 1500	22.44	36.13	51.21	36.04	7.79	3.72	24.50	3.80	445.73
All together	-	161.00	228.00	-	-	-	-	-	-

Table 3.25. Energy demand projections in urban households (continued)

Income class in Rupees	Total requirement in 1991 LPG (mt)	Ker. (mt)	S.cok. (mt)	F.wood (mt)	D.cake (mt)	Elect. (tWh)	Total requirement in 2001 LPG (mt)	Ker. (mt)	S.cok. (mt)	F.wood (mt)	D.cake (mt)	Elect. (tWh)
Upto 500	0.02	0.06	0.03	0.53	0.19	0.46	0.03	0.09	0.04	0.75	0.27	0.65
500-1000	0.93	1.19	1.04	8.70	1.81	9.76	1.32	1.69	1.48	12.33	2.56	13.83
1000-1500	0.81	0.62	0.88	4.05	1.37	8.25	1.15	0.88	1.24	5.74	1.94	11.69
Over 1500	1.30	0.28	0.13	0.89	0.14	16.10	1.85	0.40	0.19	1.25	0.19	22.83
All together	3.07	2.15	2.08	14.16	3.51	34.57	4.35	3.05	2.94	20.07	4.97	49.00

Our energy demand estimates in urban households for 1991 and 2001, as shown in Table 3.25, is comparable with the present trend of total domestic (rural and urban households together) energy consumption pattern, shown in Table 3.26. Also, our estimates fall within the plausible range of total domestic energy requirement, as estimated by the Planning Commission for the years 1994-95, 1999-2000 and 2004-05, as given in Table 3.26 [GOI, 1986].

Table 3.26. Annaul domestic energy demand including rural and urban households

	Unit	Total consumption - All India[a]			Domestic requirement[b]		
		1987-88	1988-89	1989-90	1994-95	1999-00	2004-05
LPG	Mt	1.42	1.96	2.27	12.59	17.27	23.70
Kerosene	Mt	7.23	7.73	8.24			
Softcoke	Mt	1.74	1.75	n.a.	9.00	14.00	20.00
Firewood	Mt	n.a.	n.a.	n.a.	n.a.	n.a.	258.90
Dungcake	Mt	n.a.	n.a.	n.a.	n.a.	n.a.	150.53
Electricity	tWh	187.98	187.04	208.08	40.88	82.62	145.61

n.a. denotes not available

Source : a LPG and kerosene from [GOI, 1991]
Soft coke from [GOI, 1990]
Electricity from [CMIE, 1989]
b Projected figures are as per estimates of Planning Commission [GOI,1986]

3.7 Summary and conclusions

The consumption of energy in the domestic sector continues to dominate total energy consumption in urban areas. Broad findings of the present study in urban households, are given below :

- Cooking is the primary energy consuming activity, with its share being 62 per cent of the total energy.
- Urbanisation brings with it a shift towards use of commercial forms of energy. The share of commercial energy has gone up from 42 per cent in 1982-83 to 53 per cent in 1987-88. During the same period, consumption of LPG, kerosene and soft coke has gone up by 15 per cent, 20 per cent and 14 per cent respectively. An important reason for the increase in the consumption of kerosene

and LPG is, subsidisation of their prices. Thus the pricing of fuels, which influences fuel choice is an important policy aspect.

The poor households spend a substantial portion (14 per cent) of their total expenditure to meet the energy demand as compared to urban rich (4-6 per cent). To make matter worse, the urban poor are forced to consume fuels which are low in efficiency (as low as 30 per cent as against 83 per cent in the highest income category), high in cost and being smoky, cause health hazards.. It is imperative that an integrated policy of energy prices and supplies, covering all fuels (including electricity) is evolved, which would meet the twin objectives of equity and efficiency.

Total useful energy consumption goes up as the level of income rises. With increase in income of households, there is a shift from firewood to kerosene and then on to LPG. The quantum of electricity usage also increases. For instance, firewood and dungcake consumption in the poor households (income less than Rs.500/month) meet nearly 68 per cent of the total energy demand. The remaining 32 per cent is met by LPG (5%), kerosene (15%), soft coke (3%) and electricity (9%). On the other hand, electricity, LPG and kerosene are the major fuels used by the households with income over Rs.6000 per month to meet their total energy demand. However, regional variations of energy

consumption across different income categories is found to be significant, with Northern region consuming the highest (3659 MJ/capita/year) and Eastern region consuming the least (1494 MJ/capita/year), in terms of useful energy.

- There appears to be some correlation between city size and the energy consumption pattern. But this is directed more by supply constraints (non-availability of kerosene, LPG etc.) rather than by consumer choice, Also, electricity consumption norm is found to be higher in the large size cities. For instance, the city of Delhi (with population over 6 million) consumes 10 times more electricity (612 kWh/person/year) than a small town with population less than 20,000.

- Per capita electricity consumption goes up with increase in the per capita income, (r = 0.68). The reason being, electrical appliances have become popular in higher income households, due to easy availability and ease of use.

Chapter 4

TRANSPORT SECTOR

4.1 Introduction

The contribution of the transport sector (including communication) to total GDP went up from 4.7 per cent in 1980-81 to 5.0 per cent in 1988-89 [NPC, 1991]. The gross value added by the transport sector grew by 7.1 per cent annually, during the same period.

Road based transport modes play a vital role in the urban transport system in India. Its share with respect to the total value added in the transport sector grew from 49 per cent to about 56 per cent during the period 1980-81 to 1987-88. The growth of urban population with the expansion of geographical area and generation of socio-economic activities leads to the conversion of walk-trips into vehicular trips. As the city grows, the business and economic activities tend to get concentrated in a single center or a couple of centres and the residential colonies spill over into suburbs. This trend intensifies commutation to work places, schools, shopping centres etc. which leads to an increase in trip length.

In the early stages of city growth, the vehicular trips are all road-based and are confined to modes like cycles, personalized cars, two-wheelers and intermediate public transport (IPT) like cycle rickshaws, tongas (horse driven), taxis, three-wheelers etc. As the city population and size

grows further, commuter trips tend to get concentrated on particular sections and routes and call for a larger transport unit like a mini-bus or a standard-bus which forms part of the public transport system.

In small and medium size cities, two wheelers and slow moving vehicles like cycles, cycle rickshaws and tongas are the predominant modes of transport, with little or no organized IPT modes like three-wheelers, taxis and also public transport. In larger cities, IPT modes and public transport system plays a very important role in addition to personalized cars and two wheelers. These road based motorised modes will continue to form the predominant transport system in the foreseeable future. Since, these road based systems are dependent on oil, a large portion of which is being imported in the country, it becomes important for urban planners to plan for greater efficiency of energy use in urban transport to reduce the oil import bill.

Transport, as a service, is a derived demand. First, it relates to the number of people to be carried and, second, the average distance covered. Broadly, the number of people to be carried is correlated to the size of the population and level of economic activity, whereas, the average lead is dependent more on the form and structure of the urban area.

Traffic and transportation planning studies conducted so far in India were limited to a few cities. As a result,

constraints have been felt at the decision making levels for planning of the transportation systems in cities of various sizes. Keeping in view of these requirements, the present study attempts to identify various factors by analysing secondary data on 13 cities of different sizes which influence urban travel demand and its energy implications. The specific aspects of road based passenger transport that have been studied across different large and medium size cities are : number of vehicles, modal split, modal shift, trip length, volume of trips, passenger car units, level of economic development, etc.

Finally, transport energy demand projections for cities with population more than 0.25 million, have been made for 2000-2001 under two scenarios :

Scenario I - As per present trends of vehicular growth,

Scenario II - As per recommendations of the National Commission of urbanisation.

4.2 Vehicle production and composition

Production of motorised vehicles has grown exponentially - with an average growth rate of nearly 14.5 per cent per annum between the period 1981 and 1989 [ACMA, 1990]. The annual growth of cars has been very high (19.7 per cent) during the same period. The number of two and three wheelers has also been growing at the rate of 16.5 per cent. On the other hand, the number of buses has shown a declining annual growth rate of 1.2 per cent, clearly indicating the shift from public transport to personalized

transport. There has been a drastic change in the composition of vehicular production in the last two decades as shown in Figure 4,1.

Figure 4.1 shows, two-wheelers as the most popular mode of urban transport and its share out of the total vehicles has grown from 64 per cent in 1975 to as high as 76 per cent in 1989. In the case of bus, the corresponding share has gone down from nearly 4 per cent to about 1 per cent. If this trend continues congestion on roads will increase further and traffic speeds will reduce resulting in decreasing energy efficiency.

4.3 Database and methodology

Traffic and transportation problems start aggravating when a city attains a population of 500,000 [CRRI, 1988]. Eighteen representative cities, each having population above 500,000 spread over various districts of India, where transportation studies were conducted, have been identified (Table 4.1). Data on travel related parameters are compiled for these cities, from different reports to understand the factors that influence urban travel demand. A detailed correlation exercise is carried out between different factors and the results are presented in the subsequent sections.

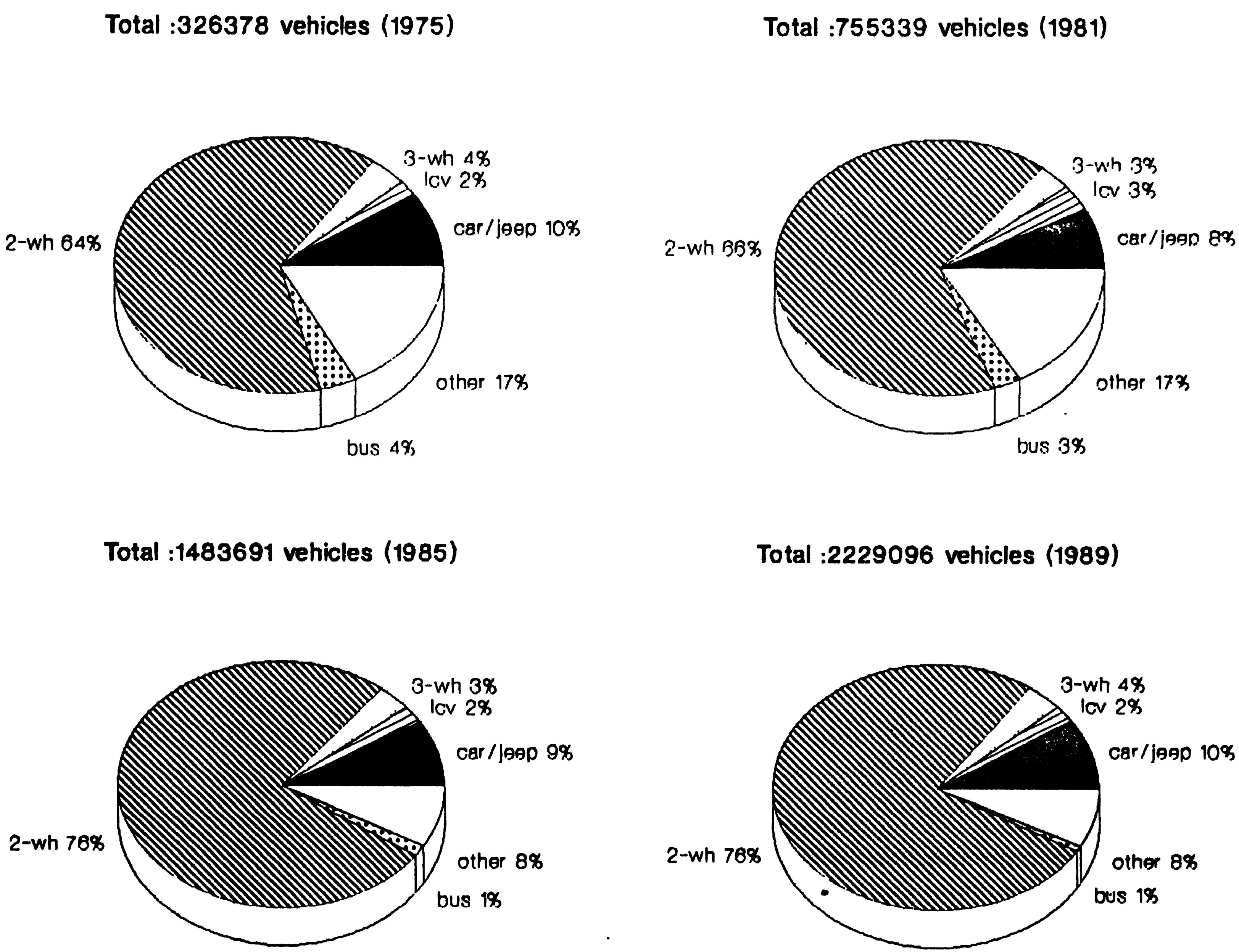


Fig.4.1: Changing composition of vehicle production

Table 4.1. Population of cities identified for the study

	Total population (million) 1971	Total population (million) 1981	Annual growth rate (%)	% of urban population in 1981	City population (million) 1981
Calcutta	7.42	9.19	2.16	100.0	2.16
Bombay	5.97	8.24	3.28	100.0	3.28
Delhi	4.07	6.22	4.33	92.7	4.01
Madras	2.58	3.28	2.43	100.0	2.43
Bangalore	3.37	4.95	3.92	64.5	2.53
Ahmedabad	2.91	3.88	2.92	71.8	2.10
Hyderabad	1.68	2.26	3.01	100.0	3.01
Pune	3.18	4.16	2.72	47.3	1.29
Kanpur	3.00	3.74	2.22	46.3	1.03
Nagpur	1.94	2.59	2.93	56.8	1.66
Jaipur	2.47	3.42	3.31	36.6	1.21
Lucknow	1.62	2.01	2.18	52.6	1.15
Madurai	3.94	4.54	1.43	36.2	0.52
Patna	2.25	3.02	2.99	37.1	1.11
Coimbatore	2.58	3.06	1.72	50.5	0.87
Vadodara	1.98	2.56	2.60	37.2	0.97
Bhopal	0.57	0.89	4.56	76.2	3.47
Cochin	n.a.	0.51	n.a.	100.0	0.51

n.a. denotes not available
Source : [GOI, 1987(a)]

4.4 Traffic growth and composition

Table 4.2 presents the growth and composition of motor vehicles registered in the eighteen cities selected for the study. The growth of motor vehicles varies considerably from one city to another. In Madras the annual growth rate of vehicles is found to be as high as 93 per cent, whereas in Coimbatore the corresponding growth rate is only about 9 per cent. One noticeable feature about the growth in motor vehicles is, explosion in the number of two wheelers like motor cycles, scooters and mopeds in these cities. In most of the cities (except Calcutta, Bombay and Cochin), the two-wheelers constitute about 60 to 80 per cent of the total vehicles. In the case of cars and jeeps together, the corresponding share varies between 8 and 44 per cent in all

Table 4.2 : Growth of vehicles and its composition

	Year	Total vehicles (thousand)	Annual compound growth (%)	Vehicle composition in percentage					
				Two-wheeler	Three-wheeler	Car, jeep	Taxi	Bus	Others
Calcutta	1986-87	351	14.63	39	1	44	4	1	10
	1985	286							
Bombay	1986-87	524	13.74	36	8	42	7	1	7
	1985	432							
Delhi	1986-87	1112	20.47	69	3	19	1	1	6
	1985	841							
Madras	1986-87	373	93.11	63	2	25	1	1	8
	1985	139							
Bangalore	1986-87	359	18.30	72	3	18	1	2	5
	1985	279							
Ahmedabad	1986-87	232	19.77	71	12	12	neg	2	3
	1985	177							
Hyderabad	1986-87	303	45.86	77	5	11	neg	1	6
	1985	172							
Pune	1986-87	213	21.02	72	7	10	1	1	9
	1985	160							
Kanpur	1986-87	127	26.75	80	2	8	neg	neg	10
	1985	89							
Nagpur	1986-87	98	11.71	79	3	9	1	1	8
	1985	83							
Jaipur	1986-87	163	18.10	66	2	13	1	4	14
	1985	127							
Lucknow	1986-87	124	31.75	77	1	9	1	1	11
	1985	82							
Madurai	1988-89	53	23.26	70	1	12	2	2	12
	1987-88	43							
Patna	1987-88	73	31.10	71	4	12	12	1	10
	1986-87	56							
Coimbatore	1987	150	9.11	81	2	12	(b)	1	4
	1982	97							
Vadodara	1987-88	188	12.33	70	6	11	neg	5	8
	1985-86	149							
Bhopal	1988	101	14.10	74	(a)	8	5	1	12
	1985	68							
Cochin	1988	60	11.37	57	8	27	5	3	n.a.
	1984	39							

(a) included in taxis
(b) included in cars and jeeps
neg denotes negligible
n.a. denotes note available

Source : Data on the first 12 cities are compiled from [ACMA, 1990]. Whereas, for the remaining cities data is compiled from [CIRT, 1987-89] reports.

the cities. The composition of vehicles in these cities shows that personalized vehicles account for at least 80 per cent of the total vehicles, while public transport buses account for only about 2 per cent. Thus, it can be seen from Table 4.2 that in the cities with population over 6 million, cars have a larger share (a little over 40 per cent) while in the other cities, two-wheelers are predominant.

4.5 Expenditure on transport

The household income influences the choice of mode for work trips. Table 4.3 presents the average household income in some selected cities and their corresponding expenditure on transport to meet the travel demand. The share of expenditure on transport out of the total income varies between 9 and 13 per cent in these cities.

Table 4.3. Monthly per household expenditure on transport by different modes of transport

Cities		Monthly household expenditure (Rs.)					Household monthly income (Rs.)
		Personalised vehicles	Cycle/ autorickshaw	Public transport	Sub-urban trains &	Total	
Bangalore	1988	210.37	18.80	60.51	1.32	291.00	2201
		(72.30)	(6.50)	(20.80)	(0.45)		
Ahmedabad	1988	115.03	34.17	37.41	2.11	188.72	1772
		(60.90)	(18.10)	(19.80)	(1.10)		
Hyderabad	1989	84.14	26.78	49.31	1.46	161.70	1572
		(52.00)	(16.60)	(30.50)	(0.90)		
Pune	1987	139.36	34.66	30.43	2.65	207.10	1987
		(67.30)	(16.70)	(14.70)	(1.30)		
Madurai	1988	53.28	5.19	75.76	4.81	139.04	1360
		(38.30)	(3.70)	(54.50)	(3.50)		
Patna	1989	165.40	61.50	9.15	8.38	244.43	n.a.
		(67.70)	(25.20)	(3.70)	(3.40)		
Coimbatore	1987	47.36	1.98	67.80	0.36	117.50	1435
		(40.31)	(1.69)	(57.70)	(0.30)		
Vadodara	1989	91.68	22.48	19.53	0.86	134.55	1870
		(68.14)	(16.71)	(14.52)	(0.64)		
Bhopal	1989	112.39	8.23	18.55	0.26	139.43	1591
		(80.61)	(5.90)	(13.30)	(0.19)		

Figures in parentheses are in percentage of total expenditure.
Source : [CIRT, 1987-89]

On an average, a household in Bangalore spends Rs. 291 per month on transport whereas, the corresponding expenditure in Coimbatore is found to be only Rs. 118. In Madurai and Coimbatore, the maximum share of total transport expenditure goes in for public transport and in the other cities it is personalized transport. Percentage share of expenditure on cycle and autorickshaw is relatively higher in medium size cities like Patna, Pune, Hyderabad and Vadodara. In the case of sub-urban trains, and others, the percentage share of the total expenditure is very low.

4.6 Modal distribution of passenger trips

Percentage distribution of trips among various modes for the selected cities is given in Table 4.4. In Calcutta figures on trip distribution is available only for public buses, sub-urban trains and cycle rickshaws. In Bombay, trip distribution is available only for motorised modes of transport and in Madras, the trip volume is not available for walk.

It can be seen that the trip distribution by different modes vary significantly across different cities. The mass transport system (including public and private buses, sub-urban trains) carry trips ranging between 17 per cent and 50 per cent, except in the city of Kanpur where its share is insignificant. The trip share by mass transport system in cities like Calcutta, Bombay and Madras is relatively higher, as corresponding figures for other modes are not available. Walk caters to substantial portion of trips (22 to 50 per

Table 4.4. Modal split of passenger trips.

Cities		Walk	Bicycle	Two-wheeler	Auto-rickshaw	Car/taxi	Bus		Train	Cycle rickshaw
							Public	Private		
Calcutta	1984	n.a.	n.a.	n.a.	n.a.	n.a.	72.00	a	20.00	8.00
Bombay	1986	n.a	n.a.	4.00	11.00	18.00	34.00	a	33.00	-
Delhi	1987	50.50	1.70	8.90	0.80	6.50	30.60	a	0.10	0.90
Madras	1984	n.a.	15.00	5.00	1.00	2.50	63.00	a	13.00	1.00
Bangalore	1988	27.50	3.00	13.00	1.00	4.40	50.80	a	0.30	-
Ahmedabad	1988	42.37	15.47	13.39	8.66	0.82	18.69	0.54	0.07	-
Hyderabad	1989	41.73	9.35	10.76	7.89	1.39	27.00	1.33	0.55	-
Pune	1986	38.94	17.13	17.30	6.30	1.05	13.86	4.68	0.74	-
Kanpur	1987	40.15	31.70	11.20	1.35	1.00	1.50	a	1.30	11.80
Madurai	1989	34.40	9.80	3.40	3.60	0.30	29.40	0.70	0.20	18.20
Patna	1989	21.94	16.61	22.47	13.23	7.10	-	5.06	0.98	12.61
Coimbatore	1987	44.54	13.25	6.15	1.25	0.91	33.41	0.45	0.04	-
Vadodara	1989	38.66	11.95	13.20	13.37	2.50	19.11	1.17	0.04	-
Bhopal	1989	45.37	11.38	13.78	1.68	0.88	20.35	6.49	0.07	-
Cochin	1989	38.07	6.18	10.44	1.49	1.30	-	40.16	-	2.36

a included in public bus
n.a. denotes not available

cent) in all the cities. It is important to note that the walk share is significant in almost every urban centre irrespective of its size. Urban planners therefore need to pay attention to the needs of pedestrians in designing cities. Slow vehicles which include cycle rickshaws, carry 11 to 18 per cent trips in medium size cities like Kanpur, Madurai and Patna. The two-wheelers cater to trips ranging

between 4 and 22 per cent and three wheelers between 1 and 13 per cent in most of the cities. In Bombay, 18 per cent of total trips is catered by cars and taxis.

4.7 Modes of transport and road congestion

The congestion in roads can increase either because the road length is inadequate for the traffic carried or due to the predominance of personalized modes of transport which occupy more road space per passenger carried. This leads to extreme congestion and chaos in traffic flows. The extreme road congestion affects adversely the service capability of the public bus transport system as a result of the declining speed of traffic. Due to high densities of population in the heart of the city the number of pedestrians is also too large, continually clashing with different vehicles. This severe situation not only undermines the mobility standard but also increases the accident hazard.

One norm for gauging road congestion will be in terms of Passenger Car Units (PCU's) per road kilometre. The details of PCU per road km for different cities are presented in Table 4.5.

It may be observed from Table 4.5 that there exists a wide variation in PCU per road kilometer. Calcutta has inadequate road length, while in Delhi, PCU's per kilometer of road is highest because of large population of cars, two-wheelers and also three-wheelers. Madras, in spite of being

Table 4.5. Mobility and congestion indicators for selected cities

Cities	Road length per 1000 population (km)	PCU's per[a] km of road
Calcutta	0.09	256
Bombay	0.17	230
Delhi	0.28	331
Madras	0.39	56
Bangalore	0.41	150
Ahmedabad	0.35	127
Hyderabad	0.51	203
Pune	0.31	195
Kanpur	0.58	51
Patna	0.45	100
Coimbatore	0.92	77
Cochin	0.24	144

a PCU = Passenger car units

Note: 1 Bus = 3 PCU; 2 wheeler = 0.5 PCU; 3 wheeler = 0.75 PCU

one of the largest cities in terms of population, has very low congestion level. This is because of larger road length and higher share of public transport. In all other cities the PCU per kilometer of road varies between 51 and 200. This wide variation reveals a lack in appropriate traffic management measures. This lack of policy has led to a shift in travel choice towards personalized modes, with utter disregard to road capacity.

4.8 Factors influencing travel demand

Urban travel demand depends on two components viz. total passenger trips and average trip length. Passenger trips is more dependent on the urban population and also the economic structure of the city, whereas, trip length is dependent more on the form and structure of the urban area and the manner in which land use is planned.

In order to examine the relationship between travel demand and parameters like urban size and economic structure of the city, a linear correlation and regression analysis for a cross section of cities with population over 1 million is performed (Table 4.6). For each of these cities data is compiled on the following parameters

- total population
- level of urbanisation (per cent of the total population living in urban areas)
- population density
- index of economic development [CMIE, 1985]
- bus share of the total passenger trips
- number of trips made daily
- average trip length
- passenger car unit (PCU)
- vehicle population

Table 4.6. Travel demand parameters and the database for selected cities

Cities	Population (million) Total	Population (million) Urban	Level of urbanisation (%)	Population density (No./sqkm)	Level of economic development (All India = 100)	Trip sphare by bus (%)	No. of trips daily (lakhs)	Average trip length (km)	PCU (thousand)	Vehicle population (thousand)
Calcutta	9.19	9.19	100	31651	942	72	92.9	5.8	205.9	286
Bombay	8.24	8.24	100	13644	1138	34	119.75	10.8	318.6	432
Delhi	6.20	5.77	93	4178	1075	62	38.96	13.4	508.8	841
Madras	3.28	3.28	100	25123	656	63	46.07	7.6	91.1	139
Bangalore	4.95	3.19	64.5	615	231	70	32.40	10.6	225.9	329
Ahmedabad	3.88	2.79	71.8	441	377	45.7	29.10	7.3	106.7	153
Hyderabad	2.26	2.26	100	10325	324	61.6	71.68	7.6	103.5	179
Pune	4.16	1.97	47.3	266	211	42.2	29.08	7.9	149.0	217
Kanpur	3.70	1.71	46.3	614	118	9.2	13.84	5.7	107.5	89
Madurai	4.50	1.63	36.2	359	109	84.7	18.70	2.9	48.0	43
Patna	3.02	1.12	37.1	951	120	9.3	10.10	3.3	51.6	73
Coimbatore	3.06	1.55	50.5	409	202	80.3	14.92	9.8	100.1	150
Vadodara	2.56	0.95	37.2	327	234	41.1	20.93	3.0	101.3	188
Bhopal	0.89	0.68	76.2	323	194	57.8	13.71	-	66.32	101
Cochin	0.51	0.51	100	5410	207	72.0	4.86	3.0	34.50	13

(a) excluding walk

4.8.1 Correlation and regression results

Linear correlation and regression results between factors influencing travel demand is presented in Table 4.7.

Table 4.7. Degree of linear relationship between travel demand parameters and urban size for 13 cities (1987-8

	Endogenous or dependent variable (Y)	Explanatory or Independent variable (X)	Degree of linear relationship (correlation r)	Linear regression			Figu
				Constant	X-coefficent	R^2	
1.1	Total passenger trips daily [lakhs]	Urban population [million]	0.85	5.87	10.60 (5.36)	0.72	4.
1.2	log (Total passenger trips daily)[lakhs]	log (Urban population) [million]	0.83	1.13	0.88 (5.09)	0.70	
2	Passenger car unit [thousands]	Urban population [million]	0.66	56.63	31.69 (2.94)	0.44	4.
3.1	Level of urbanisation [%]	Economic development index	0.82	42.14	0.06 (4.67)	0.66	4.
3.2	log (Level of urbanization) [%]	log (economic development index)	0.88	0.70	0.44 (6.06)	0.77	-
4	log (population density) [persons/sqkm]	log (level of urbanisation) [%]	0.85	-3.35	3.66 (5.39)	0.73	4.
5	Passenger car unit [thousand]	Vehicle population [thousand]	0.99	18.30	0.60 (20.22)	0.97	4.
6	Total passenger trips daily [lakhs]	Level of urbanisation [%]	0.81	-26.31	1.00 (4.54)	0.65	4.

Note : Figures within '( )' indicate t-statistics with 11 degree of freedom
Figures within '[ ]' are the physical units

The analysis establishes a significant linear relationship between :

(1) Total trips daily and urban population, r = 0.85 (Figure 4.2)

(2) Passenger car unit and urban population, r = 0.66 (Figure 4.3)

(3) Level of urbanisation and index of economic development, r = 0.82 (Figure 4.4)

Fig.4.2: Urban population & trip volume

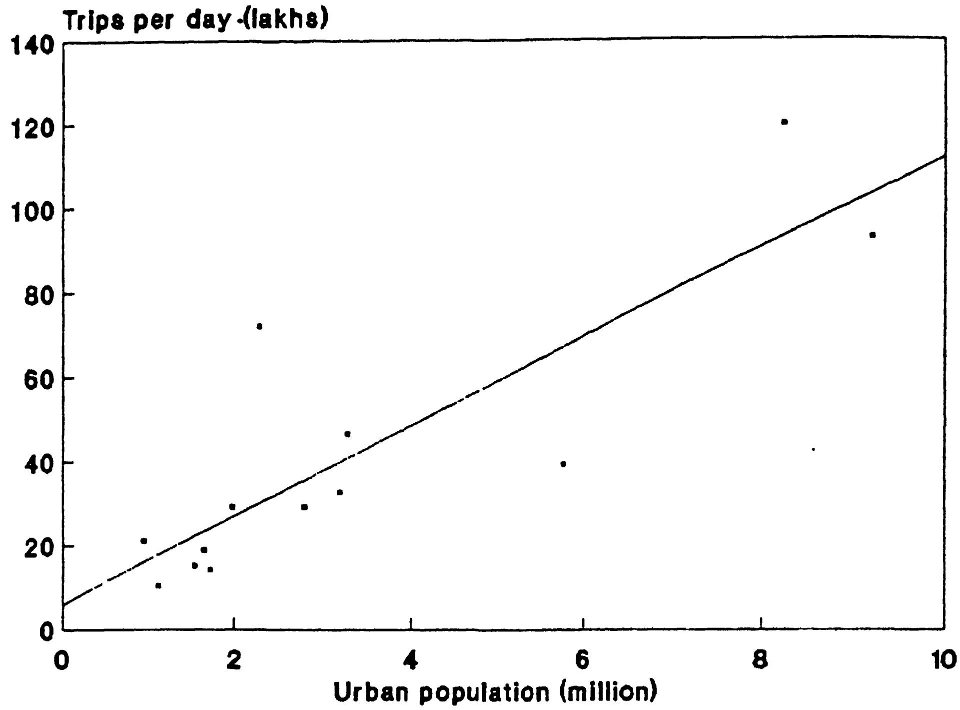


Fig.4.3: Urban population & PCU

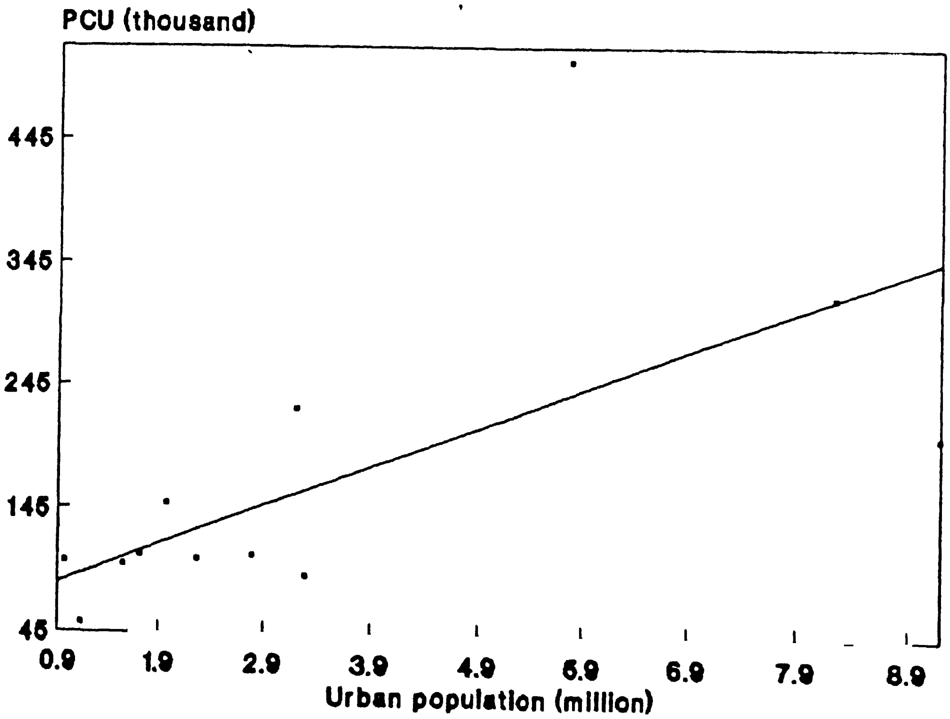


Fig.4.4: Economic index & urbanisation

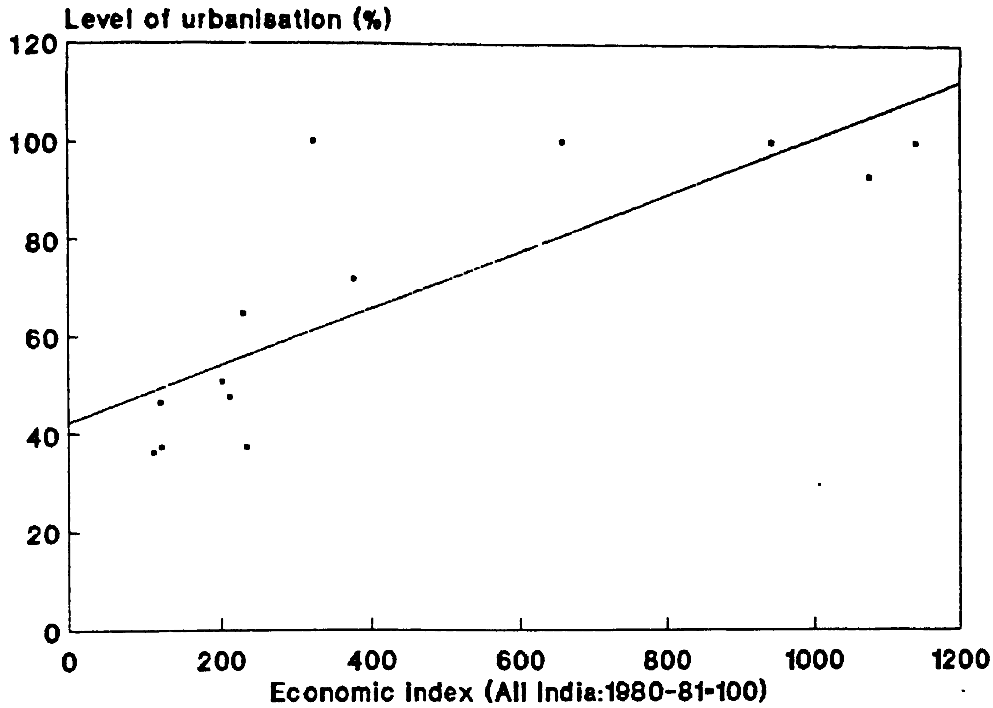


Fig.4.5: Urbanisation & popn. density

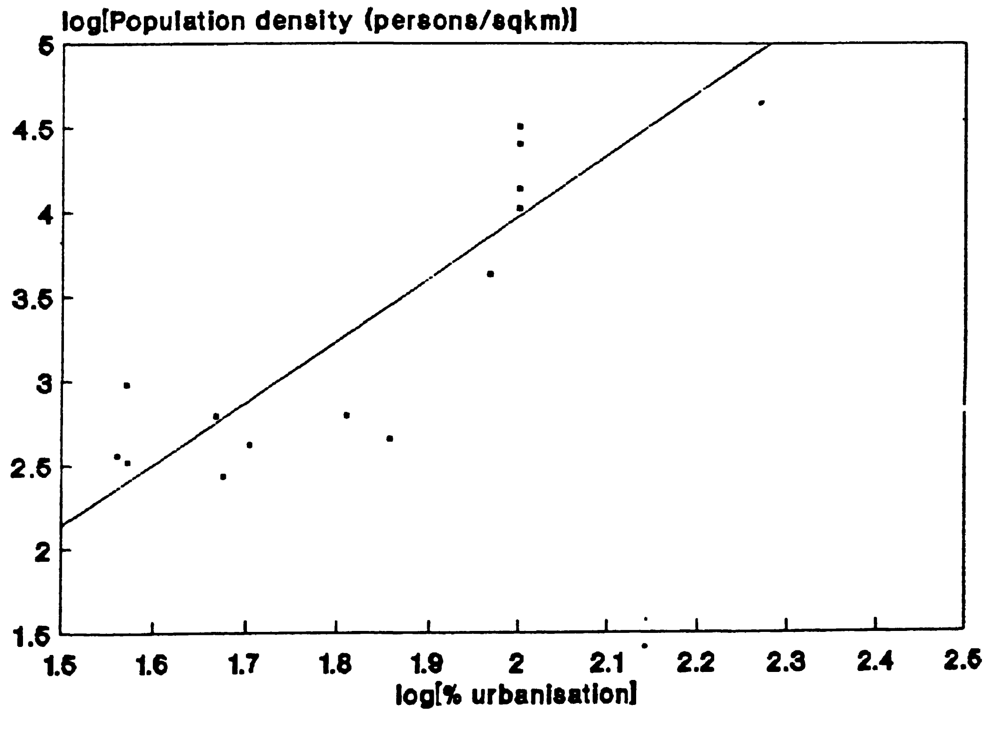


Fig.4.6: Vehicle population & PCU

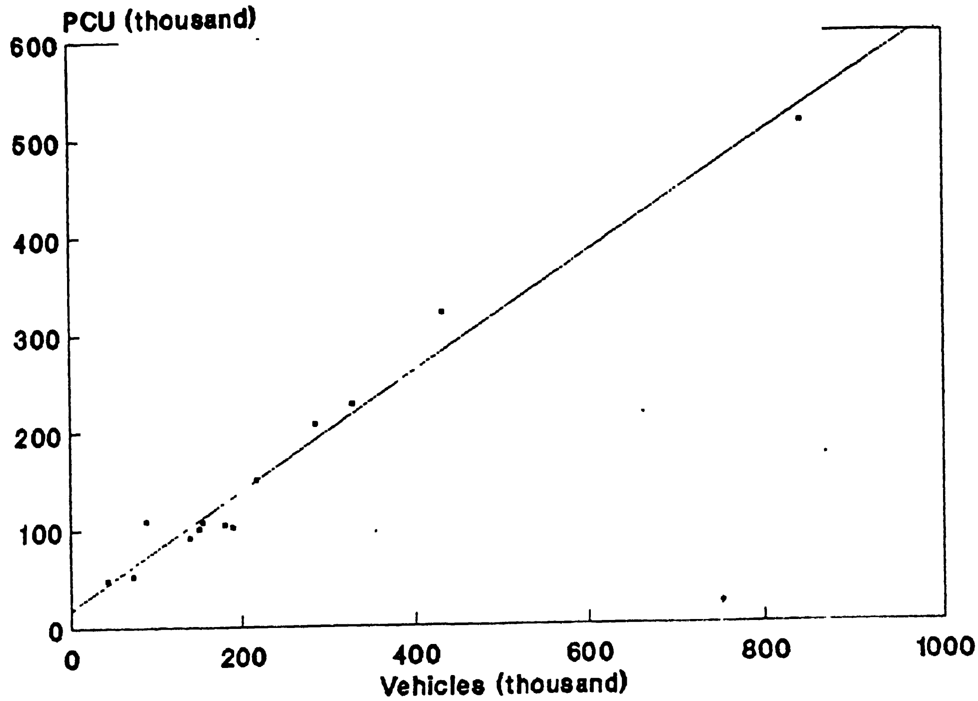
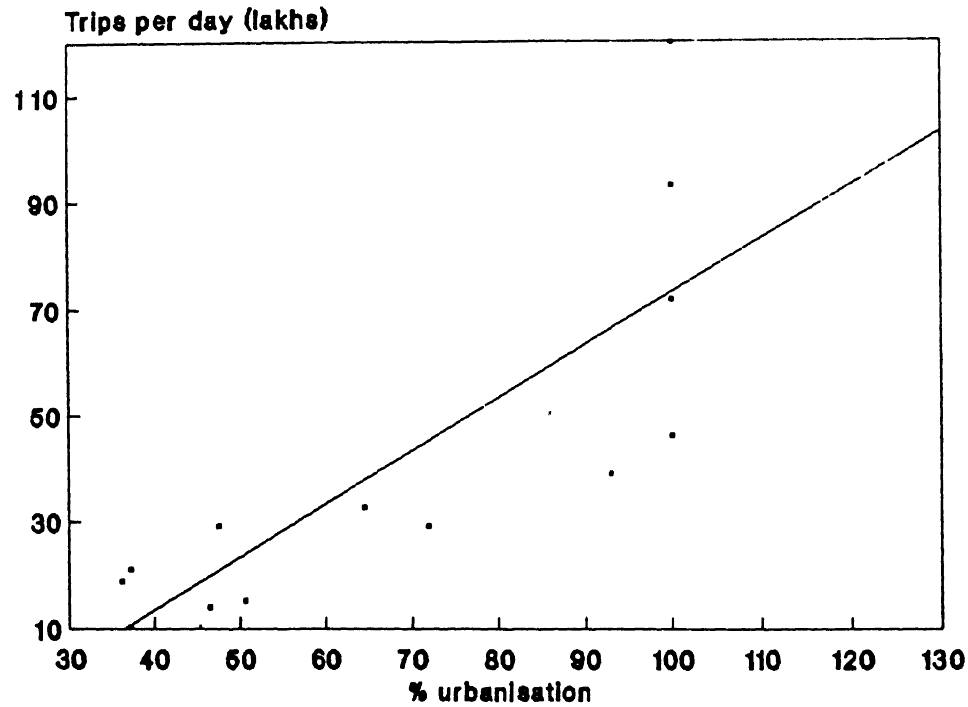


Fig.4.7: Urbanisation & trip volume



(4) Urbanisation and population density, r = 0.75

(5) Passenger car unit and vehicle population, r = 0.99 (Figure 4.6)

(6) Total trips daily and level of urbanisation, r = 0.81 (Figure 4.7)

From Table 4.7, we also get the following linear regression equations in logarithmic scale; for,

(1) total trips daily (T) and the population of the city (P),

$$\log T = 1.13 + \underset{(5.09)^a}{0.88} \log P \qquad R^2 = 0.70$$

This relationship implies, holding constant level of urbanisation, population density, economic development, trip share by bus, average trip length and vehicular population, the elasticity of total passenger trips daily with respect to a one per cent increase in urban population is 0.88. In other words, if there is one per cent increase in the total urban population, the trip volume will go up by 0.88 per cent, ceteris paribus.

(2) level of urbanisation (U) and economic development (E),

$$\log U = 0.70 + \underset{(6.06)}{0.44} \log E \qquad R^2 = 0.77$$

This implies, holding constant total urban population, population density, trip share by bus, total trips daily, average trip length and vehicular population, the elasticity of urbanisation with respect to economic development is 0.44. That is, one per cent increase

---

a indicate t-statistic

in the overall economic development of a city would bring about 0.44 per cent increase in the level of urbanisation.

(3) population density (D) and level of urbanisation (U),

$$\log D = -3.35 + \underset{(5.39)}{3.66} \log U \qquad R^2 = 0.73$$

This relationship implies, holding constant other travel related parameters, one per cent increase in the level of urbanisation would increase the city population density by 3.66 per cent (Figure 4.5).

4.8 Urban travel demand in 2001

A reliable forecast for total urban transport demand can be made only if we have disaggregated time series traffic data for different size and types of cities. Data on other socio-economic parameters, like income and employment structure would also be needed. In the absence of this, one can only make a rough assessment of the demand on the basis of some grouping of the cities into homogenous groups and arrive at the demand on a theoretical basis. This was attempted by the Study Group on Alternative Systems of Urban Transport set up by Government of India [GOI, 1987].

The parameters used by them for classifying the cities are detailed below :

(a) Population size

Symbol	Population Range	Median Population
I	8 M - 18 + M	13 M
II	4 M - 8 M	6 M
III	2 M - 4 M	3 M
IV	1 M - 2 M	1.5 M
V	0.5 M - 1 M	0.75 M
VI	0.25M - 0.5 M	0.375 M

M denotes million

(b) Urban form

C - Circular

S - Semicircular

L - Linear

(c) Spatial structure

M - Mononuclear	i.e. only one CBD
P - Polycentric	i.e. one CBD and other District Business Centres (DBC's)

In circular city, four DBCs are assumed in a ring corridor around the centre. In a semicircular and linear case 2 DBC are assumed.

In the division of employment activity between the CBD and DBCs we may have two options:

Uniform (U) - where employment opportunities in DBCs and CBD are equal

or

Non-Uniforms (NU) - where 50 per cent of employment is in CBD and balance equally shared among DBCs.

The residential population and densities are assumed to be as follows :

	C	S	L	
Inner Belt	20%	20%	10%	@ 600 persons/hectare
Intermediate Belt	60%	60%	60%	@ 250 persons/hectare
Outer Belt	20%	20%	30%	@ 100 persons/hectare

On the basis of the above parameters, the classification of cities in India in 2001 is expected to be as shown in (Table 4.8).

Table 4.8 : Expected classification of cities in 2001

Pop.Category (million)	Circular			Semi-circular			Linear			Total
	PU	PNU	M	PU	PNU	M	PU	PNU	M	
8 and above	-	3	-	-	-	-	-	1	-	4
4 - 8	1	1	-	-	1	-	-	-	-	3
2 - 4	-	2	-	-	1	-	-	1	-	4
1 - 2	-	4	5	-	1	1	-	2	2	15
0.5 - 1	-	12	18	-	1	-	1	2	2	36
0.25-0.5	1	1	14	-	-	1	2	-	2	21
Total	2	23	37	-	4	2	3	6	6	83

The travel demand is worked out by the Study Group [GOI, 1987], for each type using a gravity model of the type:

$$T_{ij} = K \; P_i \; E_j \; D_{ij}$$

where T_{ij} = number of thousand trips per day between residential zone i and activity centre j.

P_i = population of zone i (assumed to be concentrated at its centroid)

E_j = employment is in thousand at activity centre j (Participation rate of 30 per cent is assumed)

D_{ij} = distance between residential zone i and activity centre j in kilometers

K = a calibration constant

The model was validated for the 83 cities with population above 0.25 million in the year 2001, in the context of the specific case of Delhi metropolitan region which was found to approximate reasonably well to the actual traffic data.

On the basis of this model, the average trip rate and trip lengths were worked out by the Study Group [GOI, 1987] for the different classes of cities. The results are summarised in Table 4.9.

The total passenger trips for each size city can be projected using the regression equation :

$$T = \underset{(0.20)}{-2.39} + \underset{(13.87)}{1.11}\,P \qquad R^2 = 0.88$$

where T = total trips

P = urban population

Using the classification of cities as in Table 4.8 and the trip lengths as in Table 4.9, the total travel demand for the 83 cities in the year 2001 is estimated by the Study Group [GOI, 1987], and presented in Table 4.10.

Table 4.9 : Trip rate and length for different class cities

Pop Category (million)	Average Trip Length (kms)								
	Circular			Semi-circular			Linear		
	PU	PNU	M	PU	PNU	M	PU	PNU	M
8 +	10.0	11.1	-	11.6	11.6	-	22.6	23.0	-
4 - 8	6.8	7.5	-	7.9	7.9	-	10.5	10.7	-
2 - 4	4.8	5.3	4.0	5.6	5.6	5.6	5.2	5.4	4.8
1 - 2	3.4	3.8	2.8	3.9	3.9	3.9	2.6	2.7	2.4
0.5 - 1	2.4	2.7	2.0	2.8	2.8	2.8	1.3	1.3	1.2
0.25-0.5	1.7	1.9	1.4	2.0	2.0	2.0	0.7	0.7	0.6

Source : [GOI, 1987]

Table 4.10 : Projections of urban travel demand

Population range (million)	Medium population	No. of cities	Population (million)	Travel demand BPKM per year
8 and above	13	4	52	314.5
3 - 8	6	3	18	59.8
2 - 4	3	4	12	25.9
1 - 2	1.5	15	22.5	25.6
0.5 - 1	0.75	36	27	15.6
0.25-0.5	0.375	21	7.9	1.4
Total		83	124.4	442.8

Of the total projected urban travel demand of 442.8 billion passenger kilometer (BPKM), travel demand on road will account for 80% and the rest 20% will be catered by suburban rail traffic.

4.10 **Transport energy demand in urban areas**

Total travel demand (on road) will be around 358 BPKM, in 2001 for cities with population over 0.25 million (Table 4.10). Energy demand for 2001 has been estimated based on this travel demand. Essentially, energy requirement in the transport sector will depend on (1) total travel demand which remains fixed for a particular year and (2) modal split which may vary depending upon the transport policy.

Thus, for the energy demand projections we have considered the following two scenarios.

Scenario 1 : modal split as per present trends of vehicular growth, and

Scenario 2 : increasing the share of public buses to improve the overall energy efficiency, as per recommendations of the National Commission on Urbanisation (NCU).

Table 4.11 presents the total petroleum demand in the 83 cities during 2001 to meet the travel demand by road.

Table 4.11. Urban energy demand projections in the passenger transport during 2001

	Unit	Scenario 1 As per present trends					Scenario 2 As per NCU recommendations				
		Bus	Car	Two-wheeler	Three-wheeler	Total	Bus	Car	Two-wheeler	Three-wheeler	Total
Modal split	(%)	57	9	22	12	100	80	4	10	6	100
Annual passenger kilometer	(10^8)	205	33	80	40	358	288	14	36	20	358
No. of vehicles	(10^3)	62	1173	7809	532	9576	87	488	3542	260	4377
PCU	(10^3)	186	1173	3904	532	5795	261	488	1771	260	2780
Fuel demand	(10^3TOE)	1270	1012	1277	733	4292	1786	421	579	359	3145

Source : [GOI, 1987]

Table 4.11 reveals the following :

Total demand of oil goes down by 27% in scenario 2 (i.e., by increasing the share of public buses from 57% to 80%) than scenario 1. This means a saving of 1.15 million tonnes of oil. The other advantages are reduction in number of vehicles and PCU by more than half.

The increase in the number of buses required in the recommended scenario is 25,000. At today's cost this would

mean an additional investment of Rs. 1,000 crores. If we add 30 per cent for investments in infrastructure we need only Rs. 108 crores per year till the turn of the century to provide the requisite additions to buses.

One disadvantage in the recommended scenario (Scenario 2) is that about half a million tonne of diesel fuel will be required in addition, implying additional imports. This can be got over if two further measures are implemented :

- increasing the traffic carried by electrical suburban rail systems in metropolitan cities by 50 per cent more than that projected by the Railways (i.e. 26 BPKM more) giving a saving of 160 thousand tonnes of diesel.
- improving fuel efficiency of buses from 3.5 kmpl to 4.5 kmpl leading to a saving of 400 thousand tonnes of diesel. This could be done partly by technological improvements in bus design and partly by traffic management measures leading to less congestion and faster flow of bus traffic.

The question that may be asked is, "will people shift to public transport?" Experience in India shows that in cities where there is a clean, effective and efficient bus transportation (either public or privately operated) urban residents do shift to the bus mode. This is evident from the high percentage of bus mode in many cities in South India and the popularity of the privately operated 'chartered bus' system in Delhi.

It is, therefore felt, that the modal split suggested above is feasible. An imaginative policy for bus transportation providing for different types of services, like express, deluxe etc. to cater to different interests would have to be implemented to wean away commuters from personalised transport to buses. A change in industrial policy in the automotive sector would also be needed. There will have to be an accelerated production of fuel efficient buses designed specifically for urban transport and a cut back on production of cars and two-wheelers.

4.11 **Summary and conclusions**

All our major cities are plagued with traffic congestion. The obvious factors responsible are the concentration of too many people and activities in too small a space, and the inefficient relationship of work places and residences. This haphazard spatial pattern of urban development and the mix of urban functions strongly influence the number and length of passenger trips, the parameters affecting urban travel demand. Transportation within and between urban settlements accounts for a major share in urban energy requirements. Various modes of transport, have different characteristics in terms of energy consumption. The modal split, which varies across the cities, has a major role to play in determining the energy efficiency in transport network. Therefore, in planning the structure of urban settlements, due regard should be paid to the amount and energy efficiency of transport required. Energy

consumption can also be reduced by designing cities with an accent on accessibility rather than mobility.

The present study has analyzed city level traffic data to understand the factors influencing urban travel demand. The major findings are listed below:

- With an increase in the size of the city (in terms of population), total trips daily goes up, (r = 0.85)
- Increase in level of urbanization (measured as percentage of total population living in urban areas) induces migration towards urban agglomerations, resulting in higher urban population density.
- Higher the index of economic development in a city, greater is the level of urbanization, (r = 0.82)

In addition to the above findings, following steps must be taken to reduce energy use in urban transport:

- Increasing the fuel efficiencies of existing modes of transport.
- Encouraging the use of public transport. For instance, an increase in bus share from 57 per cent to 80 per cent, to meet the urban travel demand, leads to a saving of oil by 27 per cent. Other advantages are a 54 per cent reduction in total vehicles on the road and 52 per cent reduction in traffic congestion.
- Ensuring a smooth flow of traffic through proper traffic management.

At present, urban development plans and designs do not give special consideration to mass public transport and non-motorised traffic. In drawing up city traffic plans, specific measures should be built-in to facilitate the efficient operation of the public transport system. The city plans should also specifically provide for properly designed and maintained bicycle paths and pedestrian walks, in order to facilitate and encourage such forms of non-motorised transport.

Chapter 5

INDUSTRIAL SECTOR

5.1 Introduction

In this chapter we would be looking at the interrelationship between the effects of urbanisation and industrial energy use. There exists a two-way causation between industrial changes and urbanisation. The scale of production in the new, energy-intensive activities generally is greater than in the traditional processes that are displaced, and the concentration of population in cities both permits and is facilitated by these industrial changes. The new production technologies, the increased competitive pressures of developed markets, and the increased scarcity of space in cities all encourage the substitution of more compact, flexible, and reliable energy forms for the bulkier, traditional, biomass fuels. Usually, these energy substitutions due to urbanisation permit a smaller total quantity of input energy to supply the same or larger energy outputs, dampening the tendency to increase energy intensity of production. However, rising per capita income associated with industrialization and, to a lesser extent, with urbanisation increase demands for both end-use energy and more energy intensive products and services [Jones, 1989].

The industrial sector in India consumed more than half (50.7 per cent) of the total commercial energy available (111 mtoe) for use, in 1988-89. In terms of different fuel shares, nearly 49 per cent of electricity, 91 per cent of

coal and 17 per cent of petroleum products was consumed in the industrial sector during the same period. The type of energy source going into an industry depends mainly on the type of industry and production process.

Industrialization, urbanisation and economic development are interrelated. The process of industrialization invariably leads to economic development, which in turn influences growing urbanisation. With an increase in urbanisation, the demand for industrial produce would go up which, in effect, would influence the industrial energy demand. Since, dominance of a particular sector is reflected in the income generated by it, the level of industrialization can be examined by studying its GDP share in the entire economy.

We have, in this study, analysed time series data on the following parameters from various secondary sources [ASI, 1973-74 to 1986-87], [NPC, 1991] and [NIUA, 1988].

- Number of factories
- Number of employees
- Energy consumption
- Value of output
- Value added
- GDP due to industries
- Rates of urbanisation

The following sections examine the relationship between urbanisation, industrialization and energy use in India.

5.2 Urbanisation and industrial growth

A correlation exercise between urbanisation and development levels in different states in India reveals that the urbanisation levels are significantly related to their per capita net domestic product (r=.65) (Table 5.1). This relationship is stronger with income generated in the secondary sector (r=.69) than in the tertiary sector (r=.61). The correlation with the primary sector is as low as -.77 [NIUA, 1988].

Table 5.1. India : Correlates of the levels of ubranization by states in 1981

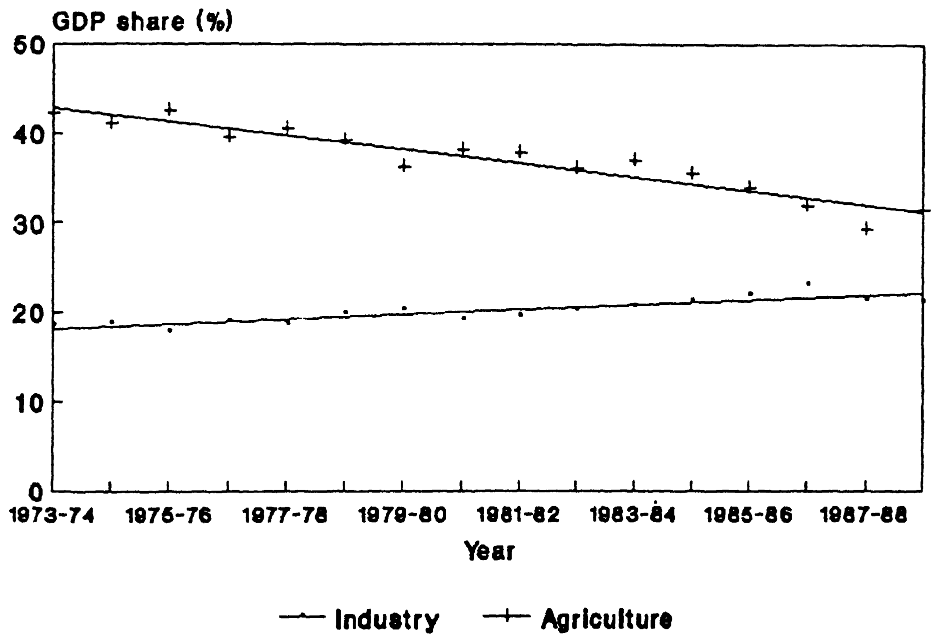
Correlates 1981-82	Coefficient of correlation with urbanisation
Per capita net national product	0.65
Share of cities in urban population	0.69
Primary sector	-0.77
Secondary sector	0.69
Tertiary sector	0.61
Per capita expenditure on public administration and other services	-0.46

Source : [NIUA, 1988]

Dominance of the primary sector is invariably associated with low levels of urbanisation. Any shift in favour of the secondary sector, which basically comprises of industries, invariably raises the level of urbanisation. The available data show that the share of primary sector (agriculture) in GDP declined from around 42.2% in 1973-74 to

31.6% in 1988-89. This was accompanied by a rise in the share of secondary sector (industries), from 18.5% in 1973-74 to 21.4% in 1988-89 (Figure 5.1). In the same time period, the employment structure has remained practically the same. This means that the output from the manufacturing and service sectors, representing urban segments, has risen much higher (a growth rate of 5.9% in the secondary sector), than that of the primary sector (2.9%), representing the rural segment. The process of urbanisation in India has, thus, helped the process of economic development and social change.

Fig.5.1: Sectoral share of GDP
1973-74 to 1988-89



5.3 Database

The Annual Survey of Industries (ASI) divides manufacturing industries into 18 major branches at the level of 2-digit code classification. In Table 5.2, the data for these manufacturing industries for the years 1973-74 to 1986-87, are summarized, according to the parameters listed in section 5.1. The consumption figures for electricity, coal and oil are converted into the units of MTCR. These values are then added to derive the total amount of energy used in the industrial sector.

It may be mentioned here that, the data on industrial sector is compiled for the factories, where a factory is defined as :

a) an establishment where 10 or more workers are working on any day of the preceding twelve months and in any part of which, a manufacturing process is being carried out with the aid of power or is ordinarily so carried on, or

b) an establishment where 20 or more workers are working on any day of the preceding twelve months and in any part of which a manufacturing process is being carried on without the aid of power, but does not include a mine or a railway running shed.

Table 5.2 : Time series data on manufacturing industries

Base 1970-71

Year	No. of factories ('000)	No. of employees ('000)	Total output (Rs.crores)	Value added (Rs.crores)	Fuels: Oil (MTCR)	Fuels: Coal (MMT)	Fuels: Elect. (MkWh)	Total energy consumption (MTCR)	Total GDP (Rs. crores)	Industrial GDP (Rs. crores)	Urbanisation (%)
1973-74	61	5141	11552	2595	8.72	24.3	46000	91.17	95192	17653	20.35
1974-75	51	5409	14075	3186	8.62	30.46	45000	99.32	96297	18193	20.58
1975-76	68	5661	17023	3473	8.50	34.01	44380	103.89	104968	18712	20.81
1976-77	78	5866	17260	3524	8.55	33.8	43300	102.55	106280	20274	21.05
1977-78	81	6221	19619	3841	8.40	33.73	46300	105.30	114219	21487	21.48
1978-79	84	6366	21274	4246	8.50	33.67	52500	111.50	120504	23985	21.93
1979-80	91	6806	20819	4057	9.00	34.00	53900	113.90	114236	23284	22.38
1980-81	93	6800	20736	3801	10.19	35.2	52600	115.59	122226	23531	22.84
1981-82	101	6851	24229	4353	11.20	39.29	52033	122.16	129776	25523	23.31
1982-83	89	7029	26566	4735	11.23	44.24	52054	129.64	133830	27295	23.91
1983-84	93	6779	26093	5056	11.48	46.78	56205	137.86	144817	30063	24.52
1984-85	95	6622	27650	5057	12.27	45.64	61613	142.34	150542	32127	25.15
1985-86	97	6468	30399	5248	13.05	49.55	65795	153.18	158176	34969	25.80
1986-87	94	6419	31430	5538	13.54	50.51	74052	163.36	164441	38246	26.46

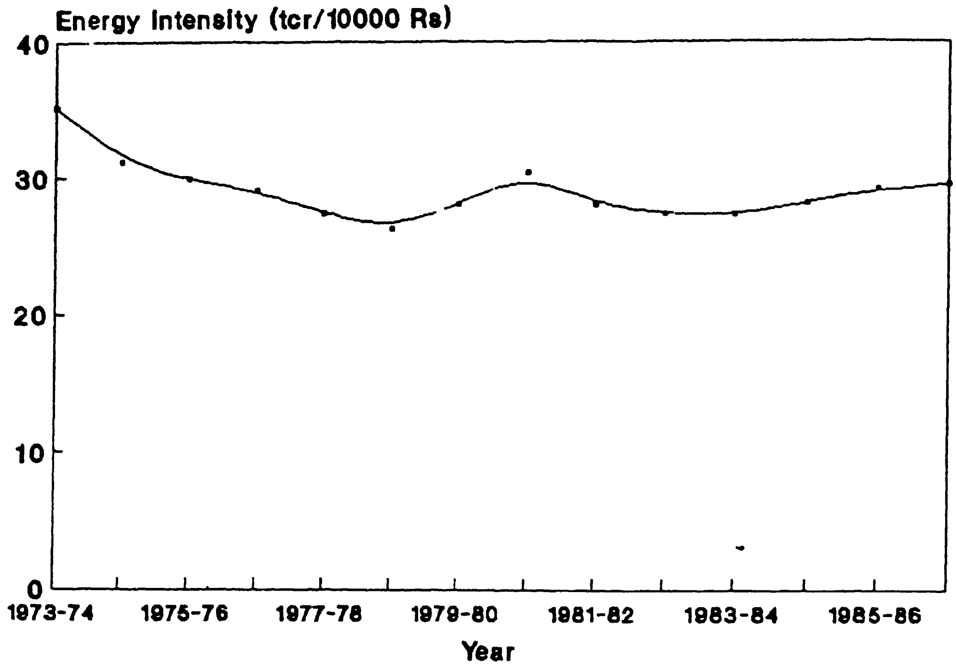
Source : [GOI, 1973-74 to 1986-87]; [NIUA, 1988] and [NPC, 1991]

5.4 Energy intensity trend

Energy intensity in the industrial sector is defined as the energy consumed per unit of value added. If we look at the trend over the period 1973 to 1987 (Figure 5.2), we see that the figures are fluctuating. We know that the value added and the energy consumption figures have a growing trend in this time period. Therefore, the possible reason for fluctuation in the energy intensity figures could be due to

the difference in the share of industries (some being more energy intensive than the others) towards value added. Due to lack of data to that effect, we have tried to restrict our analysis to value added and energy consumption separately.

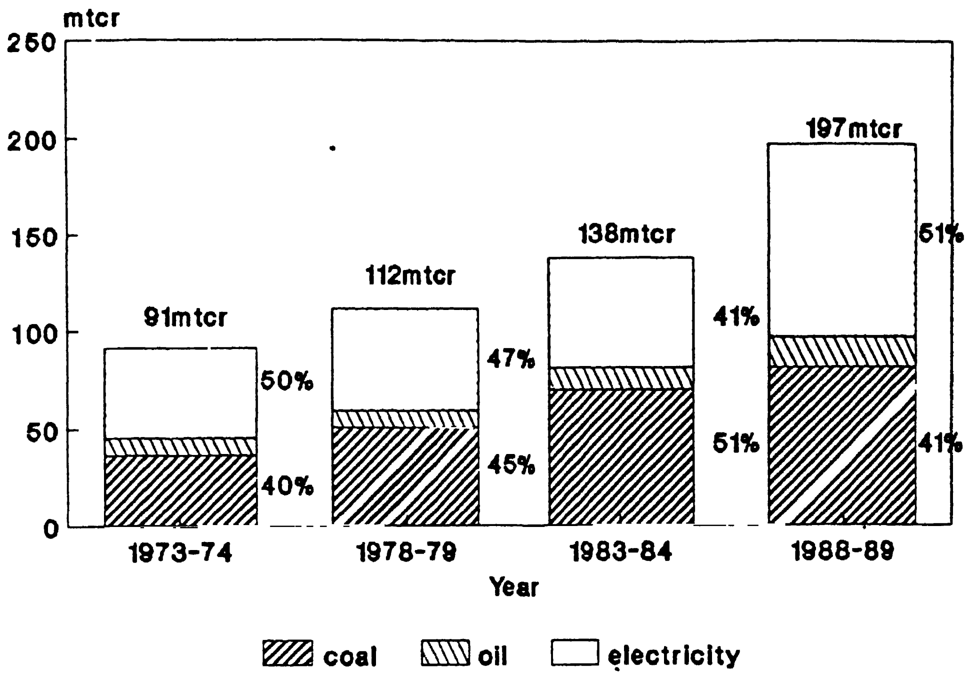
Fig.5.2: Energy intensity trend
1973-74 to 1986-87



5.5 Energy consumption in industries

The three main energy sources going into the industrial sector are coal, electricity and oil. If we look at the fuel mix trend over the years, we find that in the period 1973 to 1984, the trend is more or less uniform with coal share rising (a growth rate of 2.2%) and the share of electricity dropping steadily at the rate of 1.8%. But from 1983-84 to 1988-89 there is a sudden switch in favour of electricity share in the total energy demand (from 41% to 51%). Whereas, coal drops from 51% to 41%. The share of oil, throughout, remains more or less constant at 8% during 1978-79 to 1988-89 (Figure 5.3).

Fig.5.3: Fuel mix trend



5.6 **Correlation and regression analysis**

Figures on industrial energy intensity and productivity are derived from Table 5.2 and a correlation and regression analysis is carried out. The results are summarized in Table 5.3.

The analysis establishes a significant linear correlation between :

i) Urbanisation level and value added, r = .95 (Figure 5.4)

ii) Urbanisation level and energy consumption in industries r = .98, (Figure 5.5)

iii) Industrial energy consumption and industrial GDP, r = .99 (Figure 5.6)

iv) Urbanisation level and productivity, r = .90 (Figure 5.7)

v) Value added and energy use, r = .96 (Figure 5.8)

Fig.5.4: Urbanisation and value added
1973-74 to 1986-87

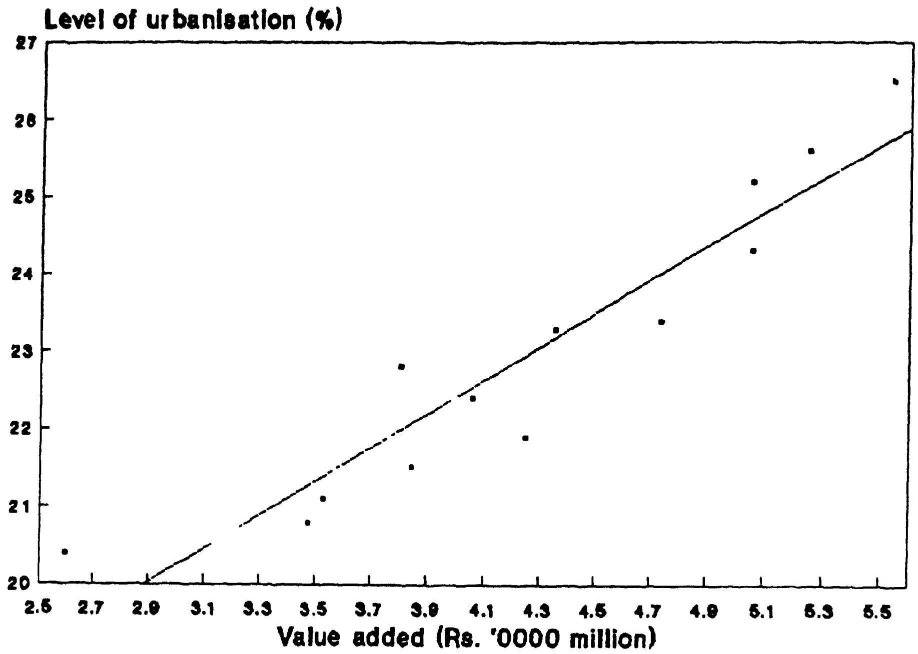


Fig.5.5: Urbanisation & energy demand
1973-74 to 1986-87

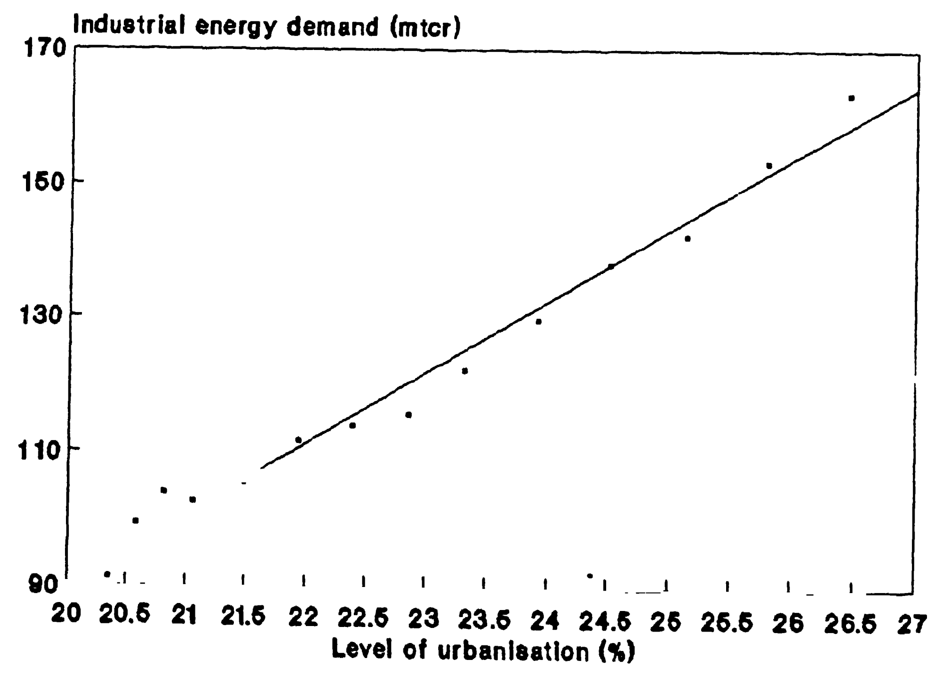


Fig.5.6: Industrial energy demand & GDP
1973-74 to 1988-89

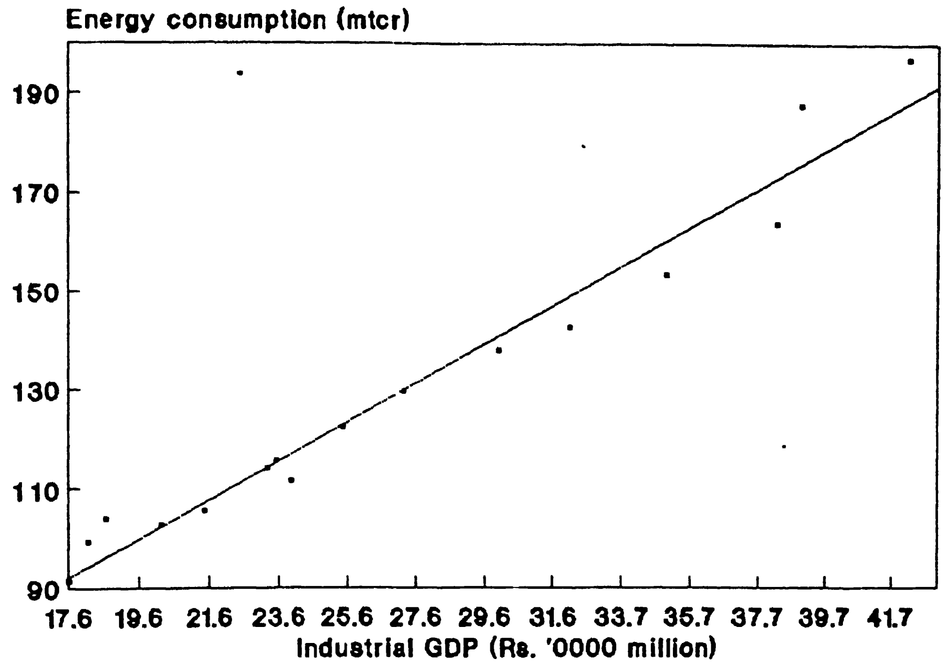


Fig.5.7: Urbanisation & productivity
1973-74 to 1986-87

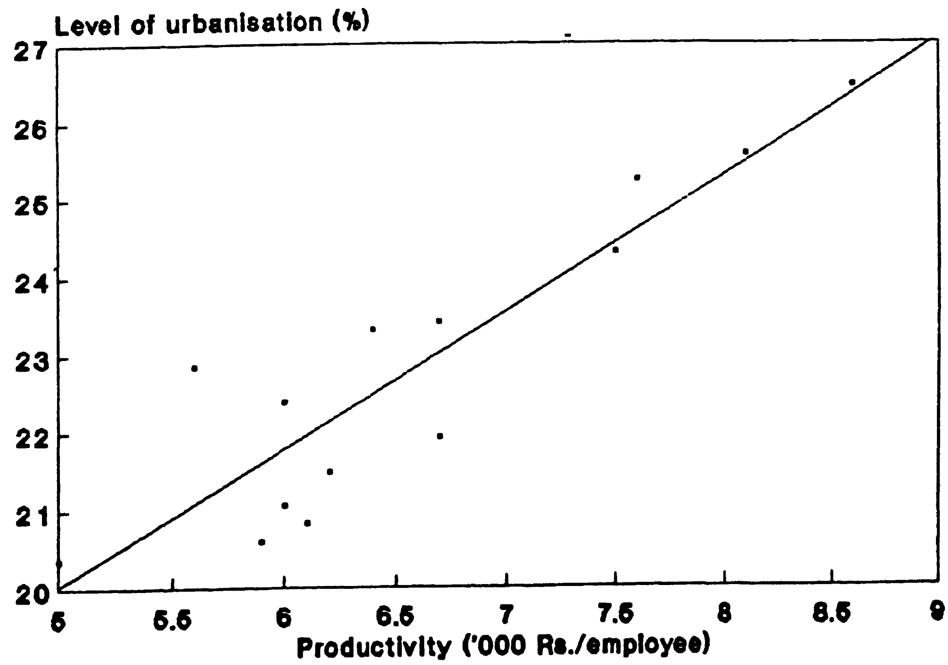


Fig. 5.8: Value added & energy demand
1973-74 to 1986-87

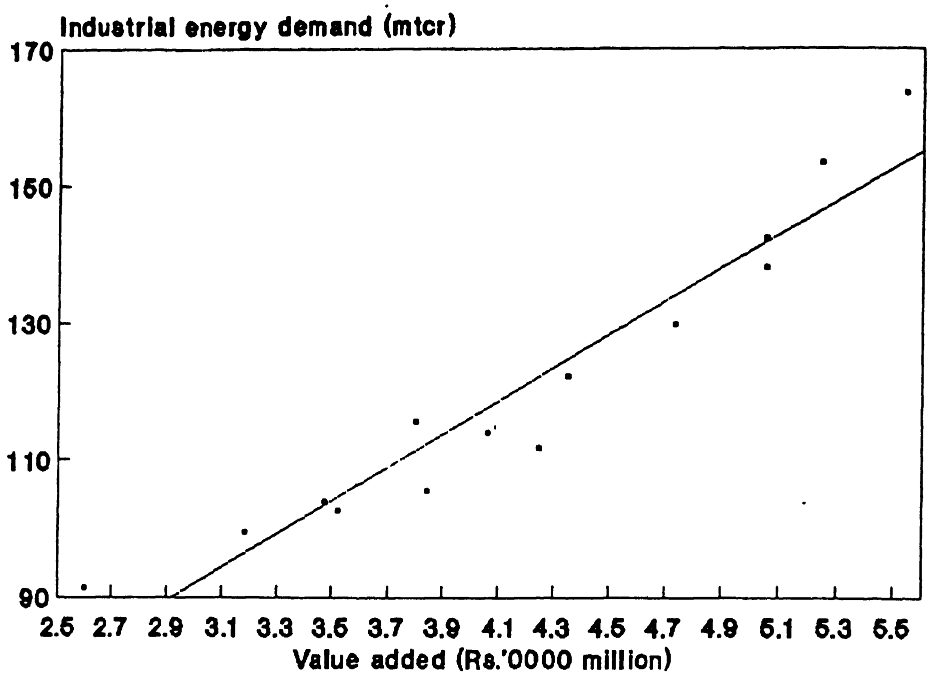


Table 5.3. Degree of linear relationship between energy demand parameters in industries and urbanisation

	Endogenous or dependent variable (Y)	Explanatory or Independent variable (X)	Degree of linear relationship (correlation r)	Linear regression Constant	X-coefficent	R^2	Figure
1	Urbanisation [%]	Value added [Rs.lakhs]	0.95	13.69	0.0002 (10.5)	0.90	5.4
1.1	log (urbanisation)	log (value added)	0.92	-0.7114	0.3685 (8.633)	0.86	
2	Total energy consumption [MTCR]	urbanisation [%]	0.99	-126.55	10.83 (22.91)	0.98	5.5
2.1	log (total energy consumption)	log (urbanisation)	0.98	-.7764	2.06 (19.27)	0.97	
3	Total energy consumption [MTCR]	GDP due to industry [Rs. crores]	0.99	36.125	0.0033 (28.22)	0.98	5.6
3.1	log (total energy consumption)	log (GDP due to industry)	0.98	-1.1268	0.7154 (19.35)	0.97	
4	Urbanisation [%]	Value added per employee or productivity [Rs.lakhs]	0.90	11.2746	175.16 (7.24)	0.81	5.7
4.1	log (urbanisation)	log (value added per employee)	0.89	1.9528	0.5027 (6.59)	0.78	
5	Total energy consumption [MTCR]	Value added (Rs. lakhs)	0.96	19.51	0.0002 (11.89)	0.92	5.8

Note : Figures within '( )' indicate t-statistics with 11 degree of freedom
Figures within '[ ]' are the physical units

The analysis also establishes a significant linear relationship among the above mentioned parameters, in logarithmic scale which gives us the elasticity figures:

i) Urbanisation level (u) and value added (v)

$$\log u = -.7114 + \underset{(8.633)^{a}}{.3685} \log v; \qquad R^2 = .86$$

This implies, that keeping other industry related parameters, like energy consumption, productivity, GDP etc. constant, the elasticity of urbanisation level with respect to value added is 0.37 i.e. if there is 1 per cent increase in value added, the urbanisation will go up by 0.37 per cent.

This suggests that economic development brought about by industrialization attracts people from the rural areas (for job opportunities), thus raising the urbanisation level.

ii) Urbanisation level (u) and energy consumption in industries (e)

$$\log e = -.776 + \underset{(19.27)}{2.06} \log u; \qquad R^2 = .97$$

This implies that holding other industry related parameters constant, the elasticity of energy consumption with respect to urbanisation level is 2.06 i.e. a 1 per cent increase in the level of urbanisation will result in a 2.06 per cent increase in the energy consumption.

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a indicates the t-statistics

This indicates that a rise in urban population would induce a greater demand for industrial goods thus increasing the energy going for producing these goods.

iii) Industrial energy consumption (e) and industrial GDP(g)

$$\log e = -1.127 + \underset{(19.35)}{.715} \log g; \qquad R^2 = .96$$

This implies that, keeping other energy related parameters constant, 1 per cent rise in industrial GDP would effect a 0.72 per cent increase in industrial energy demand.

iv) Urbanisation level (u) and productivity (p)

$$\log u = 1.95 + \underset{(6.594)}{.503} \log p; \qquad R^2 = .78$$

It can be inferred that keeping other industry related parameters constant, 1 per cent increase in productivity will induce a 0.5 per cent increase in urbanisation level.

An improvement in productivity leads to economic development which again attracts job seeking people from the rural areas, thus aiding urbanisation.

5.7 Summary and conclusions

Our study has attempted to look at the implications of urbanisation and industrialization on energy use. Industrialization brings about changes in production technologies and product mix thus affecting the energy intensity. Per capita income growth (as a result of economic

development) and urbanisation induce both direct and indirect energy demands.

An analysis of time-series data on industries offers estimates of the consequences of urbanisation and industrialization on growth in energy consumption. Holding energy consumption, productivity and GDP constant, value added elasticity of urbanisation is found to be 0.37. Keeping value added, productivity and other industry related parameters constant, the urbanisation elasticity of energy consumption is 2.06. Holding other variables constant, industrial GDP elasticity for energy consumption turns out to be 0.72.

Industrial energy intensity between 1975-76 and 1986-87 has shown a fluctuating trend (between 26 and 35 tcr/10000 Rs.). It would be difficult to pin point the reasons for this varying trend without going into a disaggregate level of energy intensity at specific industry level. It could be inferred that the shifts may have been due to changes in the share of value added by industries and also because of changes in the fuel consumption pattern and its composition.

Urbanisation alone could be a major force driving up energy consumption. Since urbanisation is, to a certain extent, driven by industrialization, by creating job opportunities for the rural folks, their joint effect on energy consumption has a possibility of getting magnified.

The key areas warranting further study regarding energy policy issues could be, trends in the development of energy intensive industries in particular and the possibility of inter-fuel substitution in the light of urbanisation process.

Chapter 6

COMMERCIAL SECTOR

6.1 Introduction

Schools, hospitals, private businesses, hotels, shops, restaurants, Government buildings, offices and other energy consuming sectors that are not included in agriculture, domestic, transport and industrial sectors comprise the commercial and services sector.

With urbanisation, the concentration of commercial activities has grown in an unplanned manner and has resulted in congestion, encroachment on public lands, traffic bottlenecks and parking problems, besides causing excessive noise in the area, thus reducing the quality of life of the resident population. The study therefore examines the relationship between growing urbanisation level and its effect on the share of GDP due to the commercial sector.

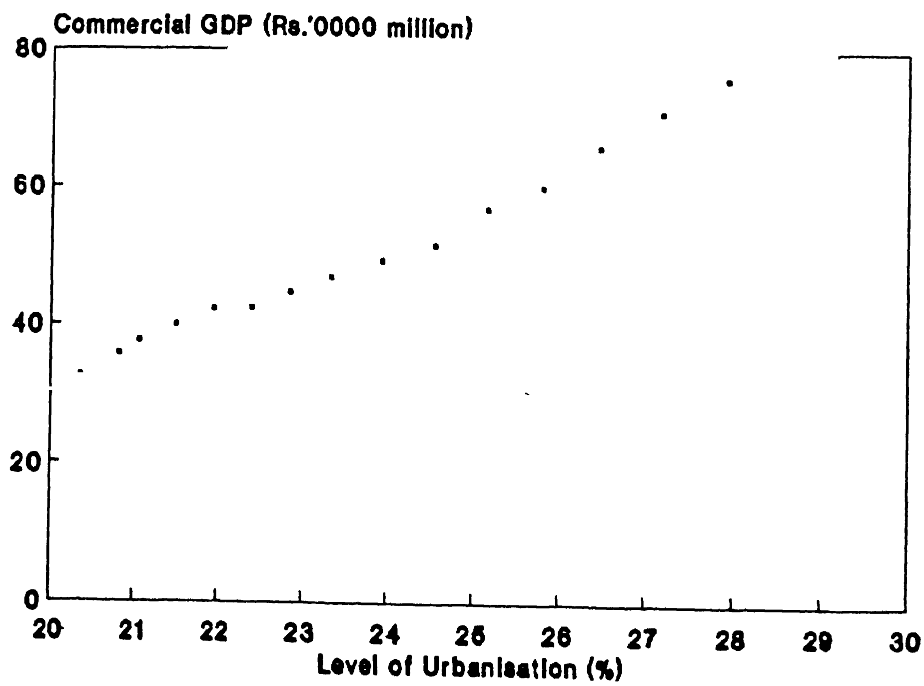
A wide variety of energy consuming activities characterize this sector. These include cooking, lighting, space heating, space cooling, refrigeration and pumping. Data on energy consumption pattern in the commercial and services sector is not available at the disaggregated level, either by end-use or by type of establishment. Only published electricity consumption statistics are disaggregated as per water and sewage supply works, street lighting, commercial buildings and miscellaneous. For other fuels it may be best to rely on information gathered through isolated sample surveys.

Due to the limited information available in the commercial and services sector, the present study has been restricted to only commercial sector comprising of retail shops. To develop database on the commercial sector, the Tata Energy Research Institute (TERI), New Delhi, conducted a questionnaire based random survey in nearly 200 shops of different types spread all over the city of Delhi during 1987. This survey data has been used only to examine the relationship between plinth area and electricity demand for lighting in different categories of shops in the city of Delhi.

6.2 Urbanisation and commercial growth

Urbanisation involves the concentration of commercial activities in different parts of the city. A linear correlation analysis reveals that level of urbanisation and GDP growth due to the commercial sector are positively correlated (r = 0.97) and is shown in Figure 6.1.

Fig.6.1:Urbanisation & Commercial GDP
1973-74 to 1988-89



During the last fifteen years (1973-74 to 1988-89), the level of urbanisation in India has gone up from 20.35 to 27.94 per cent i.e., an annual growth rate of 2.1 per cent. Over the same period the GDP share due to the commercial sector has gone up from Rs. 32483 crores in 1973-74 to Rs. 75843 crores in 1988-89, at constant price (Table 6.1). This shows a 5.8 per cent annual growth rate of GDP [NPC, 1991].

Table 6.1. Urbanisation and commercial GDP

Year	Level of urbanisation (%)	Commercial sector GDP (at 1980-81 = 100) (Rs. crores)
1973-74	20.35	32483
1974-75	20.50	33248
1975-76	20.81	35779
1976-77	21.05	3763
1977-78	21.48	39935
1978-79	21.93	42132
1979-80	22.38	42306
1980-81	22.84	44503
1981-82	23.31	46753
1982-83	23.91	49223
1983-84	24.52	51594
1984-85	25.15	56823
1985-86	25.80	60062
1986-87	26.46	65843
1987-88	27.19	70843
1988-89	27.94	75843

Source : [NIUA, 1988], [NPC, 1991].

If X denotes the level of urbanisation (%)

and Y, the commercial sector GDP (Rs. crores)

then

$$\log Y = 1.20 + \underset{(38.79)^{a}}{2.54} \log X, \qquad R^2 = 0.99$$

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a Figure in parentheses indicate t-statistic

This equation reveals that one per cent increase in the level of urbanisation would call for 2.5 per cent increase in the growth of commercial sector.

6.3 Methodology and database

The Tata Energy Research Institute (TERI), New Delhi, collected information on the distribution of different types of wholesale shops in Delhi during 1981 [GOI, 1987]. In 1981, Delhi had about 24,600 wholesale establishments. During an exercise undertaken by the Delhi Development Authority in 1981, while preparing their revised master plan, about 12,000 commodity handling shops of different categories were surveyed. The survey result had revealed that out of the 12,000 shops, the largest were textiles (17.8 per cent), followed by auto-motor parts and machinery (16.3 per cent), food articles (7 per cent), hardware and building materials (5.5 per cent) (Table 6.2).

Considering time availability and resource constraints, TERI conducted a random survey in a little over 200 shops of different types in Delhi, in 1987. The selection of different types of retail shops and its numbers are in accordance with the same distribution of wholesale shops given in Table 6.2. Using this method, the sample distribution of different types of retail shops for survey were determined and is presented in same Table 6.2.

To have a better understanding of geographical distribution of shops scattered in Delhi, various types of

retail shops are randomly selected from different parts of the city. The data is collected through a questionnaire based survey and is computerized. The same data is used to study the electricity consumption pattern for lighting according to different plinth area of various categories of shops.

Table 6.2. Distribution of different category of shops surveyed in Delhi

Category of shops	Percentage of wholesale shops in urban Delhi during 1981	Number of retail shops surveyed in Delhi during 1988
TEXTILES	17.8	36
AUTO PARTS	16.3	33
FOOD ARTICLES	17.7	35
Fruits and vegetables	7.1	14
Grocery	5.7	11
Foodgrains	4.0	8
Oil and ghee	0.9	2
BUILDING MATERIALS	11.2	22
Hardware	5.5	11
Iron and steel	3.5	7
Timber and plywood	2.2	4
CONSUMER GOODS	36.2	72
Cosmetics and toiletories	1.7	3
Footwear	0.6	1
Electrical goods	3.4	7
Medicines and chemicals	3.3	7
Rubber and plastics	3.2	6
Hosiery	2.5	5
Paper, books & stationary	4.9	10
Bicycle, tyres and tubes	3.4	7
Furniture and fixtures	1.5	3
Crockery and utensils	1.0	2
Radio and television	1.7	3
Leather and skin	2.4	3
Others	7.3	15
RESTAURANTS	-	20
Total shops	100	218

6.4 Electricity consumption for lighting in shops

Table 6.3 presents the electricity consumption pattern per unit of plinth area for lighting in different categories of shops viz. textiles; auto parts; food articles; building materials; consumer goods and restaurants.

Table 6.3. Electricity consumption for lighting per unit of plinth area in different category of shops

Category of shops	No. of obs.	kWh/sq.ft			
		Average	St.dev.	Min.	Max.
TEXTILES	37	11.46	3.71	4.47	18.87
AUTO PARTS	30	3.19	1.86	0.46	6.06
FOOD ARTICLES	31	5.02	3.08	1.07	10.65
Fruits and vegetables	11	5.69	2.93	2.28	10.65
Grocery	11	4.79	2.90	1.07	10.22
Foodgrains	7	5.03	3.64	1.31	10.35
Oil and ghee	2	2.22	0.96	1.26	3.18
BUILDING MATERIALS	17	1.95	0.95	0.46	4.17
Hardware	7	2.01	0.90	0.74	3.24
Iron and steel	6	2.09	1.15	0.46	4.17
Timber and plywood	4	1.62	0.53	0.76	2.10
CONSUMER GOODS	62	5.47	2.97	1.00	11.8
Cosmetics and toiletories	4	7.44	3.74	1.42	11.26
Footwear	6	6.86	3.74	1.00	11.80
Electrical goods	8	3.77	1.82	2.19	8.15
Medicines and chemicals	5	4.44	1.61	2.02	6.55
Rubber and plastics	4	4.74	1.97	3.11	8.03
Hosiery	6	4.33	1.83	2.26	6.92
Paper, books & stationary	9	5.55	2.65	2.15	9.86
Bicycle, tyres and tubes	5	6.45	2.26	3.05	8.94
Furniture and fixtures	4	6.05	2.43	4.33	9.49
Crockery and utensils	2	3.85	0.25	3.60	4.11
Radio and television	5	6.63	4.55	1.01	11.61
Leather and skin	1	2.92	-	2.92	2.92
Others	3	6.05	2.43	4.33	9.49
RESTAURANTS	20	3.28	1.63	0.91	6.59

Electricity consumption per unit of plinth area for lighting varies significantly across different types of shops. Average electricity consumption is found to be the

highest in the textile shops (11.46 kWh/sq.ft). Whereas, average electricity consumption pattern for lighting is almost similar (5.5 kWh/sq.ft) in shops dealing with food articles and consumer goods. The consumption figures in these categories of shops varies between 1 and 12 kWh/sq.ft. Restaurants and auto motor parts shops, consume almost similarly for lighting (3.2 kWh/sq.ft). It is found to be the lowest (2 kWh/sq.ft) in the building materials shops.

Figures 6.2 through 6.7 presents the percentage distribution of shops (viz. textiles, auto parts, grocery, building materials, consumer goods and restaurants respectively) falling in different electricity consumption block per unit of plinth area.

Fig.6.2: Electricity demand for lighting
TEXTILES

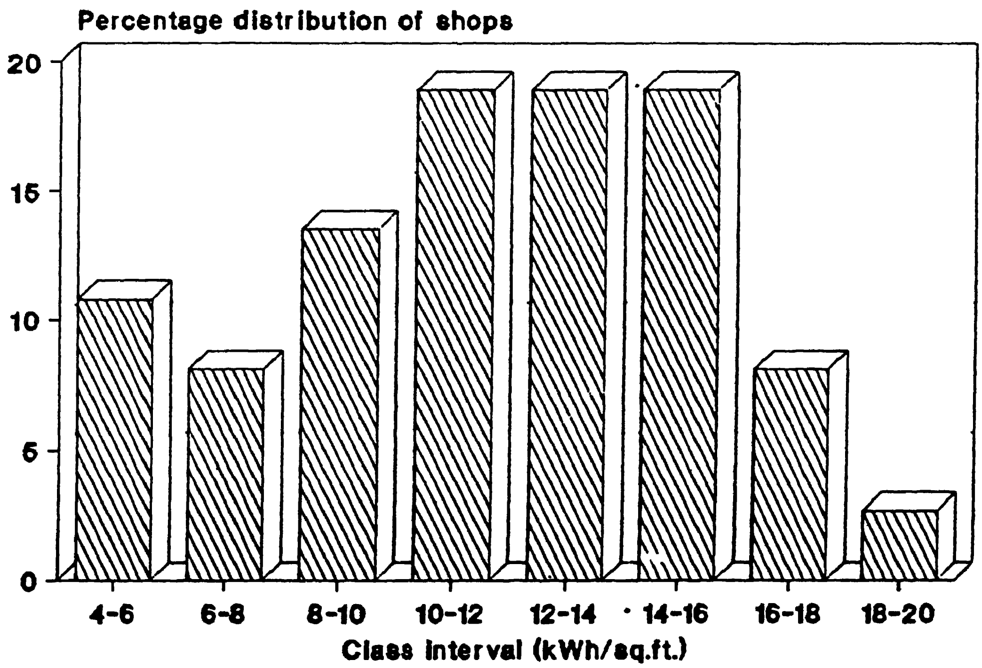


Fig.6.3: Electricity demand for lighting
AUTO PARTS

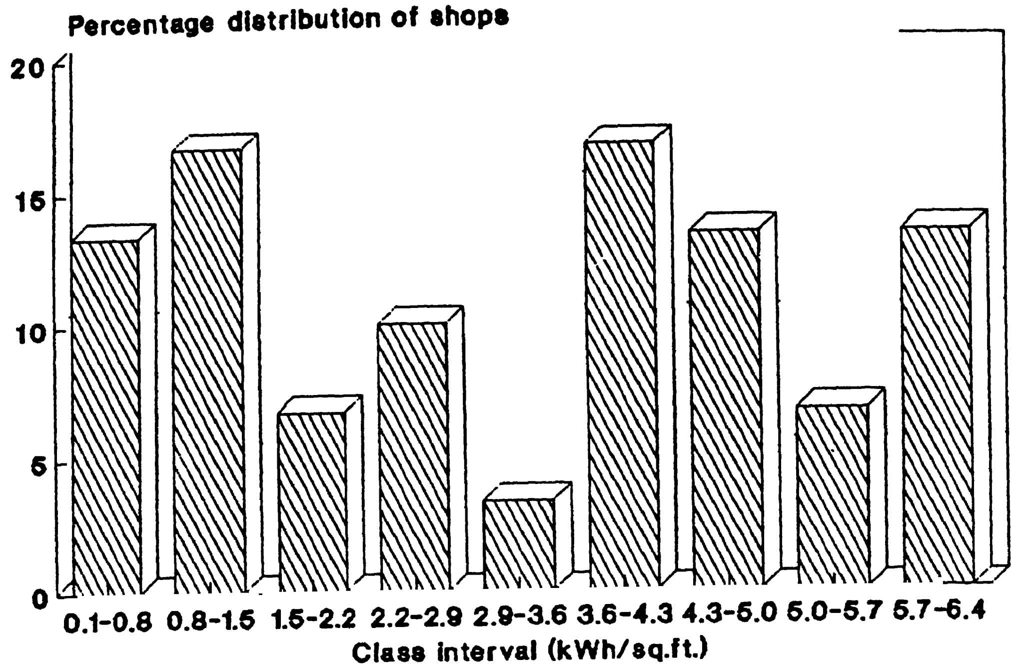


Fig.6.4: Electricity demand for lighting
GROCERY

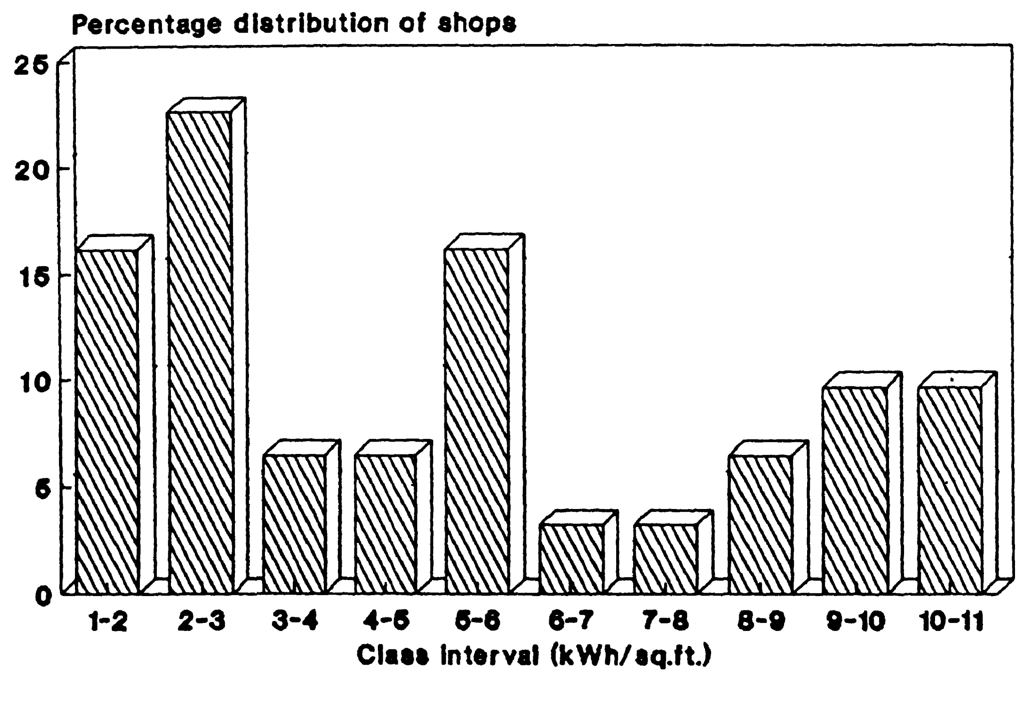


Fig.6.5: Electricity demand for lighting
BUILDING MATERIALS

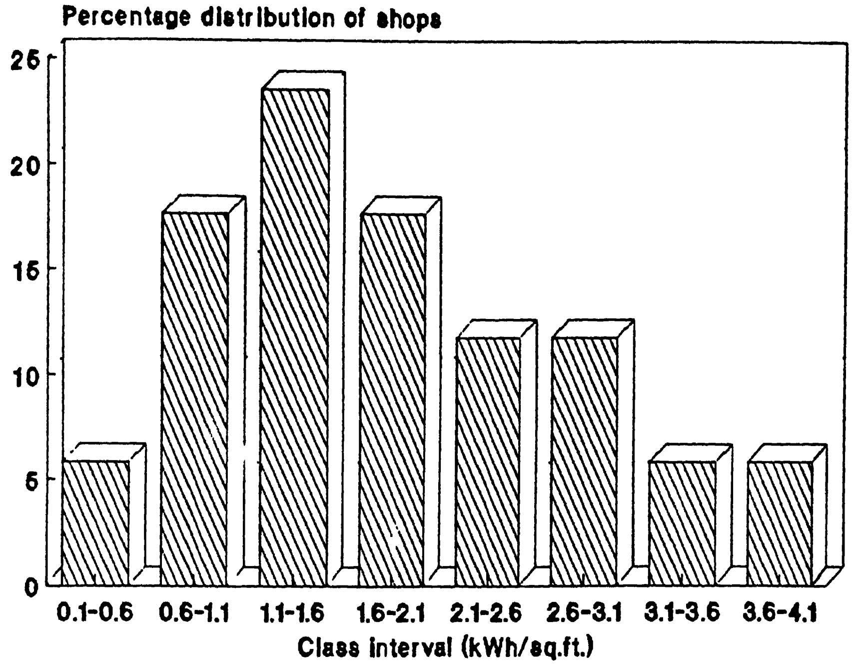


Fig.6.6: Electricity demand for lighting
CONSUMER GOODS

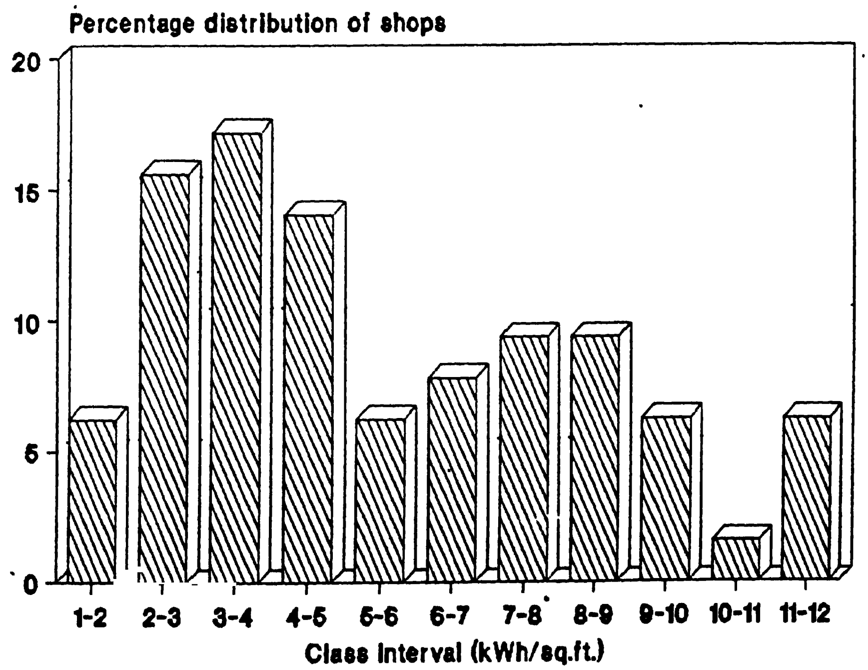


Fig.6.7: Electricity demand for lighting
RESTAURANTS

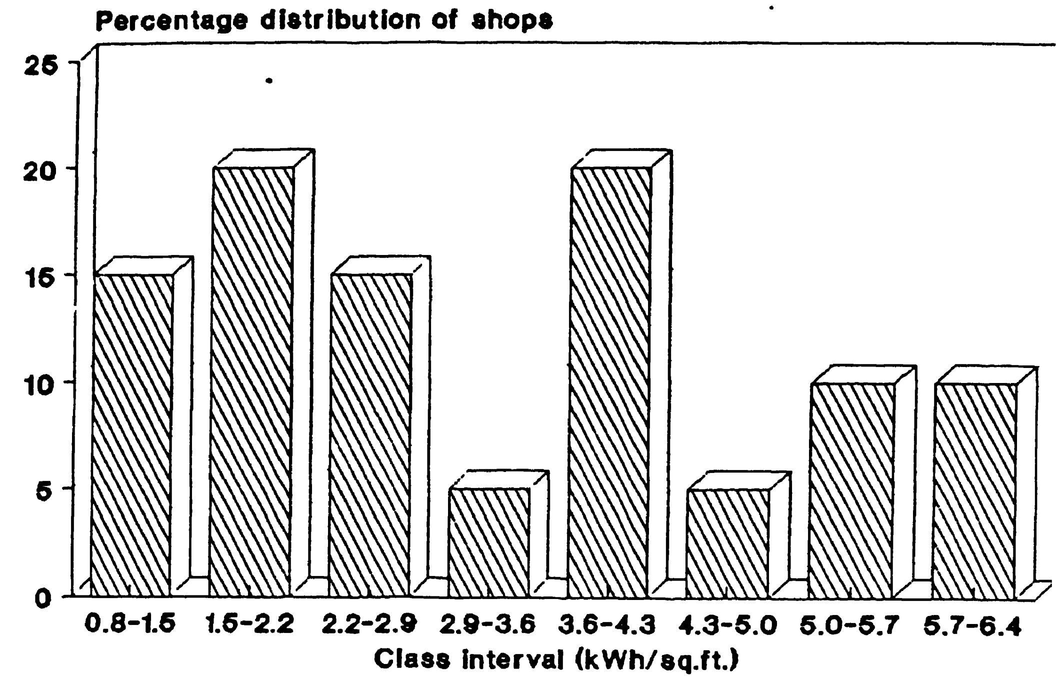
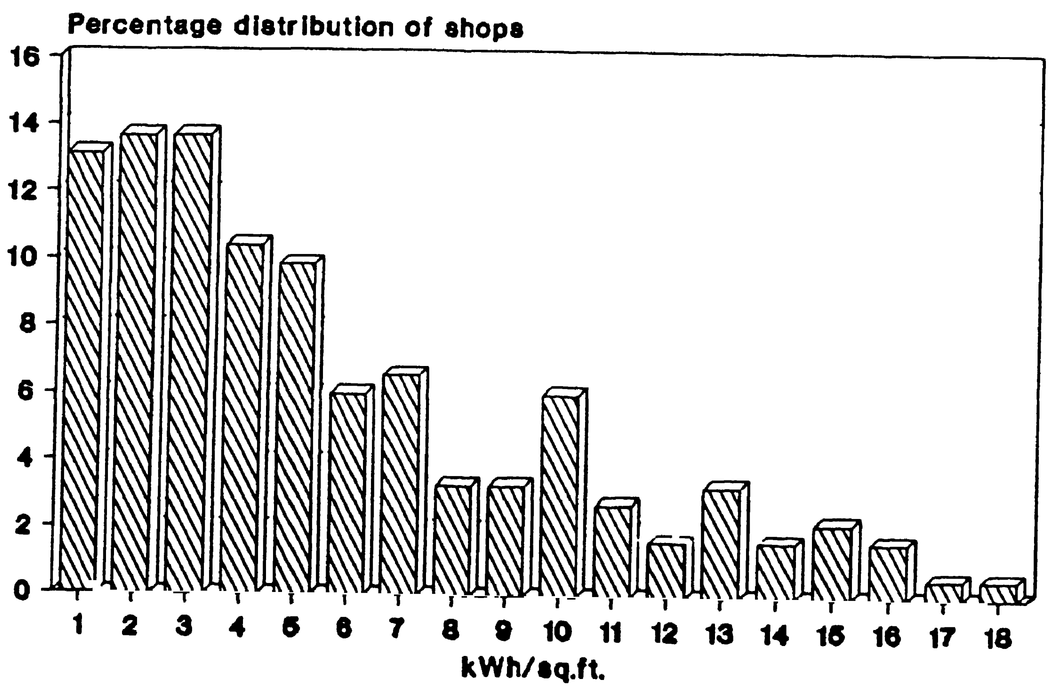


Fig.6.8: Electricity cons. for lighting
ALL SHOPS TOGETHER



Finally, distribution of all shops in Delhi with respect to different electricity consumption blocks per unit of plinth area is presented in Figure 6.8. Figure 6.8 reveals that more than half of the shops in Delhi consume electricity in the range of 1 to 4 kWh/sq.ft for lighting.

6.5 Summary and conclusions

There has been very little study on energy use in the commercial sector. However, the rapid growth of commercial establishments in many of our cities has become a major force in pushing electricity demand upwards. In the absence of detailed data, the present study has estimated the plausible range of electricity demand for lighting in different categories of shops, spread in the city of Delhi. The major finding is that more than 50 per cent of the total retail shops in Delhi, consume electricity for lighting in the range of 1 to 4 kWh/sq.ft of plinth area.

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